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Estimating Relative Juvenile Abundance of Ecologically Important Finfish in the Virginia Portion of Chesapeake Bay

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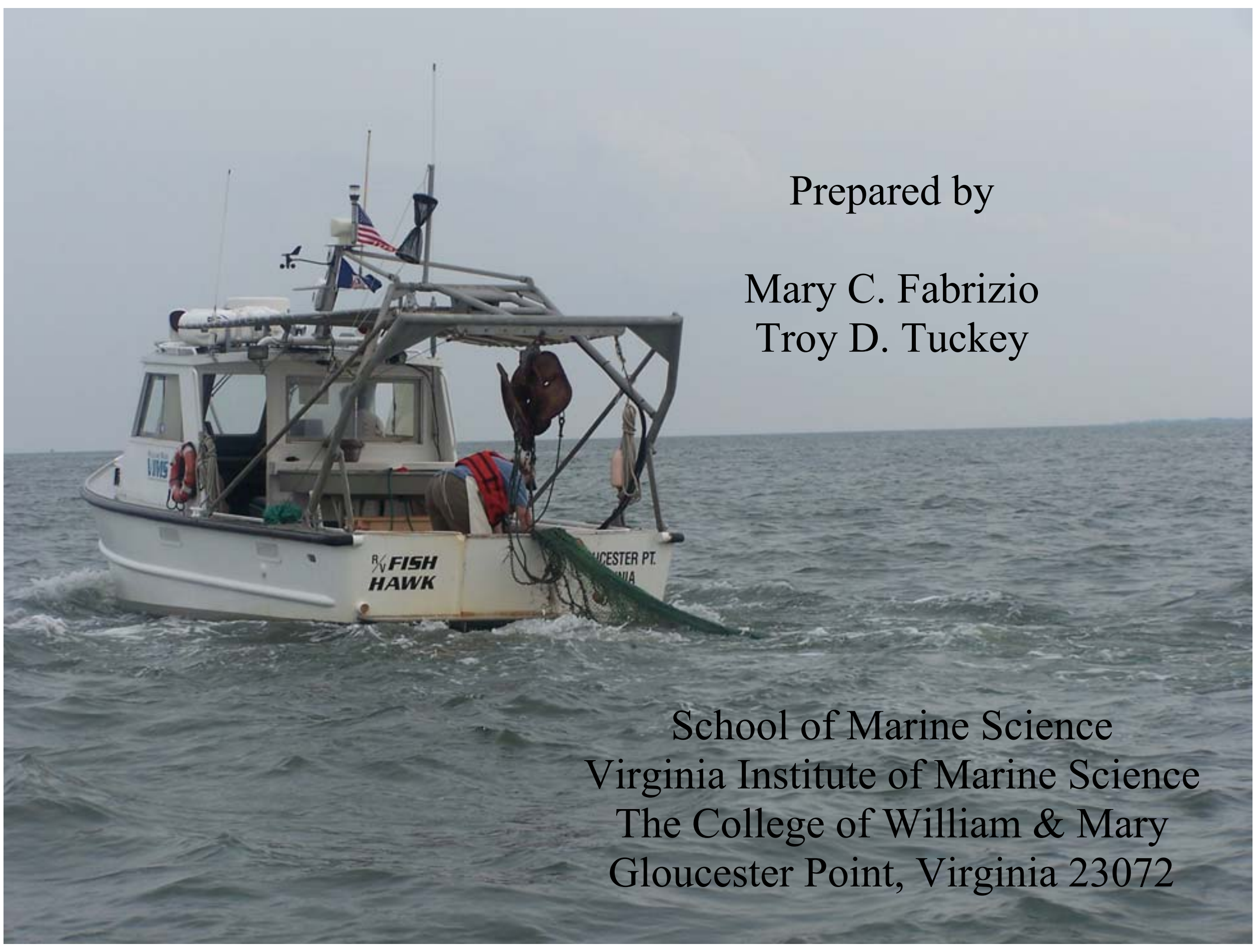

Prepared by

Mary C. Fabrizio
Troy D. Tuckey

School of Marine Science
Virginia Institute of Marine Science
The College of William & Mary
Gloucester Point, Virginia 23072

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DISCLAIMER

Some of the results contained in this report have recently been completed and may contain errors and/or need further refinement.

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EXECUTIVE SUMMARY

The fisheries trawl survey conducted by the Virginia Institute of Marine Science (VIMS) is the oldest continuing monitoring program (53 years) for marine and estuarine fishes in the United States. This survey provides a monthly assessment of abundance of juvenile marine and estuarine fishes and crustaceans in the tidal rivers and main stem of the Chesapeake Bay. The survey provides crucial data to state, regional, and national fisheries management agencies, including the Virginia Marine Resources Commission (VMRC), the Atlantic States Marine Fisheries Commission (ASMFC), the Mid-Atlantic Fisheries Management Council (MAFMC), and the National Marine Fisheries Service (NMFS). For example, the VIMS Trawl Survey provided the ASMFC with the only spot index available on the East Coast and was the cornerstone for the 2003 ASMFC Spot FMP. The MAFMC recognizes the VIMS Trawl Survey as one of the key predictors of summer flounder recruitment, and the American eel index was vital to the 2006 ASMFC American Eel Management Plan.

Several annual indices of juvenile abundance have been generated from trawl survey data for species of key recreational, ecological, and commercial importance in the Virginia portion of Chesapeake Bay. These include spot, Atlantic croaker, weakfish, summer flounder, black sea bass, scup, striped bass, white perch, white catfish, channel catfish, blue catfish, northern puffer, silver perch, blue crab, American eel, bay anchovy and Atlantic menhaden. Historically, four different estimates of relative abundance have been developed for juvenile finfish in the survey. However, only the unconverted indices (Random Stratified Index – RSI, 1988 to present) for the target species are the focus of this report.

In recent years, juvenile indices for most species have declined, most often a result of overfishing, degradation of their estuarine nursery habitats, and year-class failure due to natural environmental variation. For example, spot indices have declined greatly over the past 50 years. Atlantic croaker show the greatest interannual variability, with fluctuations likely related to environmental conditions. Weakfish recruitment indices increased since 1994, while summer flounder have remained low, perhaps due to overfishing. The scup index has been highly variable and increased slightly in 2006. Striped bass indices were low during the 1970's and early 1980's, rebounded in the early 1990's and have decreased and remained low since 2001. The white perch juvenile index decreased, while the age 1+ index increased slightly in 2007. All catfish indices decreased in 2007, however blue catfish indices (YOY and age 1+) remain relatively high compared with the early 1990’s. Since 1988, northern puffer indices experienced a rapid and continuous decline. The silver perch index has remained consistently low since 1972. American eel and bay anchovy indices decreased since the early 1980’s. The newly created Atlantic menhaden index increased slightly in 2007.

INTRODUCTION

Relative abundance estimates of early juvenile (age 0) fishes and invertebrates generated from fishery-independent survey programs provide a reliable and early indicator of year-class strength (Goodyear, 1985), and may be used to evaluate the efficacy of management actions. The Chesapeake Bay Stock Assessment Committee (CBSAC) reviewed available indices of juvenile abundance for important fishery resources in Chesapeake Bay (hereafter referred to as "Bay") and recommended that "a unified, consistent trawl program should be one of the primary monitoring tools for finfish and crab stock assessment" (Chesapeake Bay Program Stock Assessment Plan, Chesapeake Executive Council, 1988). Subsequently, pilot studies directed at developing a comprehensive trawl survey for Chesapeake Bay began at VIMS with monthly trawl sampling in the main stem of the lower Bay. This effort complemented and expanded the monthly trawl sampling conducted in major Virginia tributaries (James, York, and Rappahannock rivers).

The present sampling program, which includes the Bay and its tributaries, insures that data are of sufficient geographic coverage to generate relative abundance indices for recreationally, commercially, and ecologically important finfishes and invertebrates. The National Marine Fisheries Service Marine Recreational Fisheries Statistics Survey shows that catches in Virginia are dominated by Atlantic croaker (*Micropogonias undulatus*), summer flounder (*Paralichthys dentatus*), spot (*Leiostomus xanthurus*), striped bass (*Morone saxatilis*), black sea bass (*Centropristis striata*), bluefish (*Pomatomus saltatrix*), pigfish (*Orthopristis chrysoptera*), weakfish (*Cynoscion regalis*), and kingfishes (*Menticirrhus* spp.). These species depend on the lower Chesapeake Bay and its tributaries as nursery areas and, with the exception of bluefish, are highly vulnerable to bottom trawls. In addition to these species, species of recreational interest, such as scup (*Stenotomus chrysops*), white perch (*Morone americana*), silver perch *(Bairdiella chrysoura)*, white catfish

(*Ictalurus catus)*, channel catfish (*I. punctatus)* and blue catfish (*I. furcatus*), are taken with sufficient regularity during trawling operations to provide information suitable for the generation of juvenile abundance indices. Although annual juvenile indices are the primary focus of this project, survey results can be used to address other aspects of finfish population biology, such as habitat utilization, early growth and survival, environmental effects on recruitment, or disease prevalence. For example, episodic climatic events, such as hurricanes, affect recruitment of shelf spawning species such as Atlantic croaker (Montane and Austin, 2005).

The development of juvenile indices requires a continuous time series of data to determine the most appropriate area-time sequences for index calculations. Provisional annual juvenile abundance indices were developed for spot, weakfish, Atlantic croaker, summer flounder, and black sea bass (Colvocoresses and Geer, 1991), followed by scup (Colvocoresses et al., 1992), white perch and striped bass (Geer et al., 1994), and white catfish, channel catfish, silver perch and northern puffer *(Sphoeroides maculatus*; Geer and Austin, 1994). Recently, blue catfish, American eel (*Anguilla rostrata*), bay anchovy (*Anchoa mitchilli*) and Atlantic menhaden (*Brevoortia tyrannus*) indices were developed. Through the use of gear conversions and post stratification, a time series of index values can be produced back to 1955 for most species (Geer and Austin, 1997).

Many species of interest are captured in significant numbers across several year classes. As a result, both juvenile and age 1+ (i.e., all fish older than age 0) indices were created for white perch, white catfish, channel catfish, and blue catfish. For Atlantic croaker, both a fall juvenile index, and a recruit or spring index (returning juveniles) are calculated.

This report summarizes the activity of the VIMS Juvenile Finfish Trawl Survey from June 2007 through May 2008. Abundance indices are provided from 1988 to the present; indices generated prior to 1988 are available in previous reports.

METHODS

Field Sampling

The field sampling protocol is described in detail in Lowery and Geer (2000). In brief, a 30' (9.14m) semi-balloon otter trawl, with 1.5" (38.1mm) stretched mesh and 0.25" (6.35mm) cod-end liner, is towed along the bottom for five minutes during daylight hours. Sampling in the Bay occurs monthly except during January and March, when few target species are available. Sampling in the tributaries also occurs monthly, at both the random stratified and historical fixed (mid-channel) stations. The stratification system is based on depth and latitudinal regions in the Bay, or depth and longitudinal regions in the rivers. Each Bay region is 15 latitudinal minutes and consists of six strata: western and eastern shore shallow (4-12 ft.), western and eastern shoal (12-30 ft.), central plain (30-42 ft.), and deep channel (≥ 42 ft.; Table 1). Each tributary is divided into four regions of approximately ten longitudinal minutes, with four depth strata in each (4-12 ft., 12-30 ft., 30-42 ft., and ≥ 42 ft.) (Tables 2 - 5; Figure 1). Strata are collapsed in areas where certain depths are limited. Fixed stations have been assigned a stratum according to their location and depth (Table 5).

With the exception of the fixed river stations, trawling sites within strata are selected randomly from the National Ocean Service's Chesapeake Bay bathymetric grid, which is a database containing depth records measured or calculated at 15-cartographic-second intervals. Two to four trawling sites are randomly selected for each Bay stratum each month, with the number varying seasonally. Exceptions include the shallow water strata where one to two stations are sampled each month. For each river stratum, one to two stations are selected per month. The number of potential sites for the random stratified design (RSD) for the Bay and tributaries, along with the approximate areas of each stratum, are provided in Tables 2 – 5. Sampling in the York River has been altered slightly as of 1991 to make depth strata similar to those in the James and Rappahannock rivers and main stem Bay. The stratification scheme for the tributaries was modified in January 1996 to create depth strata of 30-42 ft. and $\geq$ 42 ft. (Geer and Austin, 1996). Tributary samples collected previously were assigned to strata established in January 1996.

Fixed stations were sampled monthly (nearly continuously) since 1980 with sites in each tributary spaced at approximately 5-mile intervals from the river mouths up to the freshwater interface. From the mid-1950's (York River) and early-1960's (James and Rappahannock rivers) to 1972, fixed stations were sampled monthly using an unlined 30' trawl (gear code 010). During 1973-79, semi-annual random stratified sampling was performed by the VIMS Ichthyology Department while the VIMS Crustaceology Department continued monitoring the fixed tributary stations on a limited monthly basis (May - November). Area-based weightings for the tributaries were previously assigned by dividing each river into two approximately equal length "strata" by assuming that the stations in each stratum are representative of the channel areas in those reaches (Table 5; see also Lowery and Geer, 2000). With all three tributaries now being sampled with a random stratified design, fixed stations were assigned to a stratum based on location and depth. The current design (combined fixed and random stations) provides greater spatial coverage, a long-term historical reference, and is more statistically sound.

All fishes collected were identified to species, counted, and measured to the nearest millimeter fork length (FL), total length (TL), or total length centerline (TLC, black sea bass only). Species that had varying size ranges were measured and counted by size class and large catches of a particular species were randomly subsampled, measured and the remaining unmeasured catch was counted. In instances of extremely large catches (i.e., bay anchovy), subsampling was performed volumetrically.

Since May 1998, habitat or substrate type sampled by the trawl gear has been recorded (Table 6). Fish distribution and abundance may be influenced by various substrates such as shell, sponge, hydroids, and sea squirts that may be used as shelter, spawning habitat or for feeding. Substrates are measured at each trawling site based on the quantity (volume in a standard container) observed in the net. Volumetric measurements of gelatinous zooplankton are also recorded for each trawl station because large catches of jellyfish and ctenophores may affect the trawl catch.

Juvenile Index Computations

Many of the target species of this study are migratory and abundance measurement presents special difficulties, particularly if the timing and duration of migration varies annually. Juvenile fishes that use estuarine nursery areas are especially vulnerable to the vagaries of the environment, as many rely on wind-driven and tidal circulation patterns for transport into the estuaries as larvae and early juveniles (Norcross, 1983; Bodolus, 1994; Wood, 2000). The outward migration of some species from the nursery area may follow annually variable environmental cues (e.g., temperature changes). Ideally, juvenile abundance should be measured when young fish are fully recruited to the nursery area under study. In practice, however, this can only be accomplished if the time of maximal abundance and size at recruitment to the gear can be predicted (and surveys timed accordingly), or if surveys can be conducted with high frequency over the season of potential maximal abundance. Neither of these two approaches is practical. The period of maximal abundance and the scope of the area surveyed have proven to be variable among years and among species. This observation, coupled with multi-species monitoring objectives, precludes temporally intense surveys. Consequently, the survey is operated with a regular periodicity (monthly) and sample-site selection is performed using a statistically rigorous approach.

A standard monthly cutoff value is applied to the length frequency information collected for each target species to partition the data into young-of-year and older components for juvenile index calculation (Table 7). Cutoff values vary among months for each species and are based on modal analyses of historical, composite length-frequency data and on reviews of ageing studies (Colvocoresses and Geer, 1991). For earlier months of the biological year, cutoff values are usually arbitrary and fall between completely discrete modal size ranges. In the later part of the biological year, when the size of early spawned, rapidly growing individuals of the most recent year class may approach that of later spawned, slower growing individuals of the previous year class, cutoff values were selected to preserve the numeric proportionality between year classes despite the potential misclassification of some individuals (Table 7). The extent of overlapping lengths and the proportion within that range attributable to each year class was estimated based on the shapes of the modal curve during the months prior to the occurrence of overlap. A length value was then selected, which results in the appropriate proportional separation. Although this process involved considerable subjectivity and ignored possible interannual variability in average growth rates, the likelihood of significant error is small, since only a small fraction of the total number of young-of-year individuals fell within the zone of overlap and most of the data used to construct juvenile indices was drawn from months when no overlap was present.

After removing non young-of-year individuals, monthly stratum-specific abundances and occurrence rates are calculated for each target species. Numbers of individuals caught are log transformed (ln(n+1)) prior to abundance calculations; the log transformation best normalizes collection data for contiguously distributed organisms such as fishes (Taylor, 1953) and is the best transformation for these data (Chittenden, 1991). Average catch rates (and the approximate 95% confidence intervals as estimated by $\pm$ 2 standard errors) are then back-transformed to the geometric means. The stratum-specific coefficient of variation is expressed as the standard deviation divided by the log-transformed mean catch: STD/ EY_{st} (Cochran, 1977). Plots and data matrices were examined for area-time combinations that provided the best basis for juvenile index calculations. Criteria applied during the selection process included identification of maximal abundance levels, uniformity of distribution, minimization of overall variance, and avoidance of periods in which distribution patterns indicated migratory behavior. Although identification of areas most suitable for index calculations (primary nursery zones) was generally clear, selection of appropriate time windows was more complex. Surveys are timed on regular monthly intervals that may or may not coincide with periods of maximal recruitment to the nursery areas. The use of a single (maximal) month's survey result is therefore inappropriate and would decrease sample size, increase confidence intervals, and increase the risk of sampling artifacts. Conversely, the temporal series of data incorporated into index calculations should not be longer than necessary to capture the period of maximal juvenile use of the nursery area. With this approach, three- or four-month periods that provided reasonable abundance data for each species were identified (Table 7).

Using these catch data from area-time combinations, annual juvenile indices are calculated as weighted geometric mean catch per tow. Stratum-specific means and variances are calculated, and combined, and weighted by stratum area (Cochran, 1977). Because stratum areas are not uniform, a weighted mean provides an index that more closely approximates actual population abundance.

The following indices are produced for each species: the original index based on the present Bay strata and the fixed mid-channel tributary stations (Bay & River Index - BRI and River Only - RO, 1988 to present) and a random stratified index using all spatially appropriate data (Random Stratified Index - RSI, 1988 to present; in previous reports, this index was referred to as the Random Stratified Converted Index, RSCI). Data collected prior to 1988 are excluded from this report because results from the longer time series are considered provisional (i.e., indices prior to 1988 require both gear and vessel conversion factors, and concerns about missing data and conversion factors for this period are being addressed). Multiple indices are presented in this report for completeness, but usually only the RSI will be described in detail.

In collaboration with the Chesapeake Bay Trophic Interaction Laboratory at VIMS, Atlantic croaker, weakfish, blue catfish, striped bass, summer flounder and silver perch were collected from the James, York, and Rappahannock rivers for diet analyses (see Parthree et al., 2008). The VIMS Trawl Survey also plays an important role responding to numerous advisory service requests (for examples, see Appendix Table 1).

RESULTS

For the 2007-2008 project year (June through May), 1294 stations were sampled resulting in 525,473 fishes identified and enumerated from 96 different species (Table 9). A summary of samples collected from 1955 through May 2008 (Table 8) provides a comprehensive synopsis of the sampling completed to date. Bay anchovy, hogchoker, and Atlantic croaker accounted for greater than 81% of the catch by numbers. If the dominant bay anchovy and hogchoker are ignored, the top five species collected, Atlantic croaker, spot, weakfish, white perch, and blue catfish represented 71% of the catch numerically (Table 9).

Examination of substrate type (inferred from bycatch in the trawl net) effects on species composition and catch may soon be possible with ten years of available data (1998 – 2007; Figure 3). The most common habitat type encountered in the survey includes detritus and hydroids, and to a lesser extent sea squirts, seaweeds and shell.

Indices were calculated and described for the following species: American eel, Atlantic croaker, Atlantic menhaden, bay anchovy, black sea bass, blue catfish, channel catfish, northern puffer, scup, silver perch, striped bass, spot, summer flounder, weakfish, white catfish, and white perch.

American eel (*Anguilla rostrata*) - American eel are a catadromous species, present along the Atlantic and Gulf coasts of North America and inland in the St. Lawrence Seaway and Great Lakes (Murdy et al., 1997). The species is panmictic and supported throughout its range by a single spawning population (Haro et al., 2000). Spawning takes place during winter to early spring in the Sargasso Sea. The eggs hatch into leaf-shaped, ribbon-like larvae called leptocephali, which are transported by ocean currents (over 9-12 months) in a generally northwesterly direction. Within a year, metamorphosis into the next life stage (glass eel) occurs in the Western Atlantic near the east coast of North America. Coastal currents and active migration transport the glass eels into rivers and estuaries from February to June in Virginia and Maryland. As growth continues, eels become pigmented (elver stage) and within 12 –14 months eels acquire a dark color with underlying yellow (yellow eel stage). Many eels migrate upriver into freshwater rivers, streams, lakes, and ponds, while others remain in estuaries. Most of the eel's life is spent in these habitats as a yellow eel. Age at maturity varies greatly with location and latitude, and in Chesapeake Bay may range from 8 to 24 years, with most eels in the Bay area less than 10 years old (Owens and Geer, 2003). Eels from Chesapeake Bay mature and migrate at an earlier age than eels from northern areas (Hedgepeth, 1983). Metamorphosis into the silver eel stage occurs during the seaward migration that occurs from late summer through autumn, as mature eels migrate back to the Sargasso Sea to spawn and die (Haro et al., 2000).

The current American eel index includes all size eels collected in the upper half of each of the major tributaries (Figure 2, JA 3 and 4, YK 3 and 4, and RA 3 and 4) during April through June. American eel indices exhibited peaks in the late 1980's and early 1990's and have declined steadily thereafter (Table 10; Figure 4, top). With the exception of two stations in the Bay, American eel were captured only the tributaries (Figure 4, bottom).

Atlantic croaker (*Micropogonias undulatus*) – Atlantic croaker are typically caught in high abundance and are widely distributed throughout the survey area (Figures 5, bottom). Spawning takes place over a protracted period, such that small juveniles (<30 mm TL) can be present in catches year-round (Norcross, 1983; Colvocoresses and Geer, 1991; Colvocoresses et al., 1992; Geer et al., 1994). For some year classes, peak abundance occurs in the fall at lengths less than 100 mm TL, but for other year classes, the peak occurs the following spring. We provide two estimates of the index: a juvenile fall index (October - December) based on catches in the tributaries, and a spring recruit index (May - August) based on catches in the Bay and tributaries combined.

Successful spawning events are evident from the abundant year classes in the fall of 1989 and 2003 (Table 11; Figure 5, top). The highly abundant 2003 juvenile croaker year class (as measured in the fall of 2003) was coincident with Hurricane *Isabel*, which struck Chesapeake Bay from 18-19 September and produced prolonged onshore winds for many days prior (Montane and Austin, 2005). The 2007 juvenile Atlantic croaker indices (fall and spring) were similar to previous, non-peak years (Figures 5 and 6, top).

Atlantic menhaden (*Brevoortia tyrannus*) – Atlantic menhaden are filter feeders and are key prey for various piscivorous species in Chesapeake Bay such as striped bass, weakfish and blue catfish (Parthree et al., 2008). Atlantic menhaden spawn in the spring (March through May) and fall (September through October) in shelf waters off Chesapeake Bay (Murdy et al., 1997). Larval migration into estuaries occurs from October through June in the mid-Atlantic (Rogers and Van Den Avyle, 1989). Larvae (10-34 mm TL) appear in the Bay in large numbers in May and June, with a smaller influx in November (Murdy et al., 1997). Brackish and freshwater areas are used by larvae prior to metamorphosing into juveniles. By fall, juveniles may reach 40-185 mm standard length (SL). In late fall, juveniles leave the Bay and migrate southward in dense schools (Murdy et al., 1997). Low dissolved oxygen events in the summer can lead to high mortality of menhaden in the Bay (Murdy et al., 1997). The 2007 Atlantic menhaden index was similar to the previous year, but well below peaks observed during 2005 and 1998 (Table 13; Figure 7, top). Atlantic menhaden were collected primarily in the tributaries with a few collections in the Bay (Figure 7, bottom).

Bay anchovy (*Anchoa mitchilli*) - Bay anchovy are the most abundant finfish throughout Chesapeake Bay and its tributaries, and are found in salinities ranging from 1-33 ‰ (Murdy et al., 1997). Bay anchovy feed mostly on zooplankton and are an important prey of other Bay fishes (Murdy et al., 1997). In years of average freshwater inflow (i.e.,1997-2000), Atlantic menhaden, bay anchovy, and Atlantic croaker often dominate fish biomass in Chesapeake Bay (Jung, 2002). Bay anchovy abundance has increased in recent years from a period of low recruitment during 2001 - 2002 (Table 14; Figure 8, top). As expected, bay anchovy are ubiquitous in trawl survey catches (Figure 8, bottom).

Black sea bass (*Centropristis striata*) - Black sea bass are seldom taken in large numbers but regularly occur in survey catches. Young-of-year black sea bass occur throughout the Bay and appear occasionally in the lower portions of the tributaries (Figure 9, bottom). Index calculations are based on all Bay strata and the lower James stratum from May through July. Although some early juveniles appear in the Bay during their first summer and fall, more young-of-year enter the estuary during the following spring. Black sea bass spawn in the summer in the Mid-Atlantic Bight (Music and Mercer, 1977). Thus, the index is calculated for the year class spawned the previous calendar year (i.e., the 2007 index is for the 2006 year class). The black sea bass RSI has been low since 2003, but has been increasing in recent years (Table 15; Figure 9, top).

Blue catfish (*Ictalurus furcatus*) - The blue catfish, one of Virginia's largest freshwater fishes (Jenkins and Burkhead, 1993), was introduced to the Chesapeake Bay area as a sportfish in the James, Rappahannock, and Mattaponi rivers between 1974 and 1989 (Virginia Department of Game and Inland Fisheries, 1989 as reported by Connelly, 2001). The blue catfish is a carnivorous bottom feeder that inhabits the main channels and backwaters of rivers (Murdy et al., 1997). Blue catfish are collected from the mesohaline portions of the major tributaries upstream to the limits of the trawl survey (Figure 10, bottom). The juvenile blue catfish RSI exhibited an increasing trend over time until 2005, after which the index declined (Table 16; Figure 10, top). Similarly, the age 1+ blue catfish RSI exhibited an increasing trend until 2005, but decreased in 2006 and 2007 (Table 17; Figure 11, top).

Blue catfish indices have increased since 1988 and the ecosystem effects of such an increase of an introduced species are unknown. However, with the increase in the age 1+ blue catfish index, indices of age 1+ white and channel catfish have decreased. Diets of small blue catfish are dominated by invertebrates (mostly amphipods, isopods and mud crabs), while larger blue catfish diets included invertebrates, menhaden, and gizzard shad (*Dorosoma cepedianum*; Parthree et al., 2008). Other catfishes (white and channel) have similar diets and may be competing with the introduced blue catfish for the same prey resources.

Channel catfish *(Ictalurus punctatus)* and **White catfish** *(Ictalurus catus)* – Channel catfish and white catfish are usually found in the upper portions of the tributaries (Figures 12, 13, 21, and 22, bottom). Although each river system is unique, spawning typically occurs in late May through early

July in Virginia (Menzel, 1945); consequently June was selected as the start of the biological year. The survey typically catches both species up to 600 mm FL with juveniles (≥ 50 mm FL) first recruiting to the gear in June. In most years, juvenile recruitment occurs from January to April for both species in the upriver strata only.

The channel catfish was introduced to Virginia in the late 1800's (Jenkins and Burkhead, 1993). Juvenile channel catfish exhibited no trend over time with a few notable peaks, while the age 1+ RSI exhibited a decreasing trend since 1991 (Tables, 18 and 19; Figures 12 and 13, top). Similarly, RSI's for juvenile and age 1+ white catfish exhibited decreasing trends over time (Tables 27 and 28; Figures 21 and 22, top).

Northern puffer *(Sphoeroides maculatus)* - Northern puffer are captured in small numbers almost exclusively in the main stem of the Bay (Figure 14, bottom). Spawning occurs from May to August in nearshore waters (Murdy et al., 1997), with peak spawning in June and July (Laroche and Davis, 1973). June is the start of the biological year with northern puffer measuring less than 50 mm TL appearing in our catches. Northern puffer is first caught in the Bay in May and usually peaks during late summer/early fall (July to October). Northern puffer indices have declined from a peak in the late 1980's and remain at low levels (Table 20; Figure 14, top).

Scup (*Stenotomus chrysops*) - Scup are primarily a marine, summer spawning species that use the Bay in a similar manner as black sea bass. The estuary is rarely used as a nursery area by early juveniles, but older juveniles can be found in the Bay during their second summer. Early juvenile scup (25-40 mm FL) occasionally appear in survey catches in June. Older scup first appear in catches in May and by June range from 50 to 215 mm FL. The original length cutoff criterion was based on ageing studies (Morse, 1978) and the trawl survey catches typically included three size or age classes (age 0, age 1, and age 2+). Because catches of age 0 and age 2+ scup are highly variable and low, index calculations are based on age 1 individuals only. The age 1 year class remains present in the Bay and available to the gear for the entire summer and early fall.

Scup are predominantly collected in the lower Bay (Figure 15, bottom). Catch rates for scup usually peak in July, and the index is calculated from catches taken in June to September. Scup indices have increased in recent years with the 2006 index approaching the maximum observed since 1988 (Table 21; Figure 15, top).

Silver perch *(Bairdiella chrysoura)* - Silver perch are found in all sampling strata (Figure 16, bottom). Spawning occurs in the deep waters of the Bay and offshore from May to July, and juveniles (100 mm TL) enter the Bay by July (Chao and Musick, 1977; Rhodes, 1971). Abundance indices for silver perch from the RSI and BRI are consistent and stable, while indices based on rivers only (RO) are always higher and show much greater variability than the RSI or the BRI indices (Table 22; Figure 16, top).

Spot (*Leiostomus xanthurus*) – Spot indices are calculated using all strata from July to October. Spot is often the most abundant of the recreational species caught by the survey, however compared with catches in the late 1980's and early 1990's, numbers have declined (Table 23; Figure 17, top). Spot are widely distributed throughout the Bay and tributaries (Figure 17, bottom).

Striped bass (*Morone saxatilis*) - Striped bass use the upper tributaries for spawning and nursery grounds and spawn from early to mid-April through the end of May, in tidal freshwater areas just above the salt wedge. Juvenile striped bass often appear in catches from May to July in size classes less than 50 mm FL during years of greater abundance, but then diminish in abundance until the following winter. A second, stronger and more consistent period of juvenile abundance occurs in December and continues through February the following year in the upper regions of the rivers. The trawl survey index for striped bass is based on this fall/winter recruitment period.

Juvenile striped bass showed strong recruitment peaks in 1993 and 2000 and have decreased in recent years (Table 24; Figure 18, top). Collections of striped bass occurred in the major tributaries with a few caught just outside the tributaries (Figure 18, bottom).

Summer flounder (*Paralichthys dentatus*) – Summer flounder spawn from late summer to midwinter (September through January) on the continental shelf with the peak occurring in October and November (Murdy et al., 1997). Flounder larvae enter the Bay and other Virginia estuaries from October through May with juveniles using shallow fine-substrate areas adjacent to seagrass beds (Murdy et al., 1997; Wyanski, 1990). Low water temperatures can have significant effects on individuals that enter the estuary in the winter (Able and Fahay, 1998). Juvenile summer flounder first appear in catches as early as late March, which is used as the beginning of the biological year. Juvenile summer flounder abundance continues to increase steadily throughout the summer and early fall to a late fall peak, and then shows evidence of emigration during December. September, October, and November usually encompass the months of greatest abundance of juvenile summer flounder. Juvenile flounder are broadly distributed throughout the Bay and lower rivers although they rarely appear in catches in the upper rivers. Consequently, index calculations include all Bay and lower river strata during September, October, and November.

Juvenile summer flounder indices were greater during the early 1990's compared with recent years, but recruitment appears to be consistent since 1995 (Table 25; Figure 19, top). Juvenile summer flounder were captured throughout the Bay and rivers including some upper river stations (Figure 19, bottom).

Weakfish (*Cynoscion regalis*) - Weakfish are one of the dominant species in our catches, and are found throughout the Bay and tributaries (Figure 20, bottom). Juveniles have occurred in catches as early as late May and June, with June considered the beginning of the biological year.

Weakfish indices (BRI and RSI) are consistent with one another and indicate steady recruitment through time, while the RO has shown greater variability and a decreasing trend since the late 1980's (Table 26; Figure 20, top).

White perch (*Morone americana*) - Spawning of white perch occurs in the upper tributaries from March to July with a peak occurring from late April to early May. Index months include December to February for juveniles and November to February for age 1+. Index stations are from the upper river strata.

Juvenile (age 0) white perch recruitment has been variable, while age 1+ recruitment exhibited a decreasing trend through time (Tables 29 and 30; Figures 23 and 24, top). White perch are collected throughout the rivers, but are most abundant in the upper river stations (Figure 23 and 24, bottom).

DISCUSSION

Juvenile indices contribute to the assessment and management of important recreational and commercial species in Chesapeake Bay and the mid-Atlantic Bight. For example, the VIMS Trawl Survey was recognized by the Mid-Atlantic Fisheries Management Council (MAFMC) as an important index of summer flounder recruitment and was instrumental in shaping more protective harvest regulations in Virginia. Additionally, the VIMS Trawl Survey supplies the only spot index available on the east coast and was essential for the 2004 ASMFC Spot FMP Review (ASMFC, 2004). Though the trawl is not the preferred gear to sample American eel, eel indices from the trawl survey played an important role in the 2006 ASMFC American Eel FMP (ASMFC, 2006), and the U.S. Fish and Wildlife Service American Eel Status Review.

Efforts continue on validating recruitment indices including size ranges and months that are used in the calculations. Additionally, new indices for species of emerging importance, such as Atlantic menhaden, are under development and revision. Furthermore, the VIMS Trawl Survey also provides a basis for monitoring species interactions. For example, annual catch rates of channel catfish and white catfish have declined since 1991, while catches of the introduced blue catfish have increased dramatically (Connelly, 2001; this report). Because diets and distributions of the species overlap, the observed trends may be due to competition and warrant further study. Furthermore, the shift in diet of older blue catfish to include other fishes may affect ecosystem function.

Declines in catches of important recreational species may be associated with degradation of estuarine nursery habitats, overfishing, poor recruitment, or a combination of these factors (Murdy et al., 1997). Although it is not possible to determine the cause of recruitment variability from trawl survey data alone, some general observations are possible. Spot are oceanic spawners and year-class strength appears to be controlled by environmental factors occurring outside the Bay (Homer and Mihursky, 1991; Bodolus, 1994), however spot indices have declined greatly over the past 50 years. Atlantic croaker show the greatest interannual variability with fluctuations possibly related to environmental conditions that vary annually. Norcross (1983) and Murdy et al. (1997) found that cold winters increased mortality in overwintering juvenile Atlantic croaker and during some years may "push" the spawning population further south, preventing access to nursery areas in Chesapeake Bay. Weakfish indices have remained low since the mid-1990's, and the decline may be attributed to both habitat degradation and overfishing. Declines in summer flounder have been observed and may be due to overfishing or year-class failure (Terceiro, 2006). Striped bass display great recruitment variability and one or two strong year classes may dominate the population at any one time (Richards and Rago, 1999). After closure of the fishery in the mid- to late-1980's due to overfishing, poor recruitment, and low stock abundance (Richards and Rago, 1999), the striped bass recruitment index peaked in 1987. Finally, white catfish and channel catfish indices, while variable, have decreased over the past 19 years, possibly due to competition with blue catfish.

The VIMS Trawl Survey supplies critical data for management of fishery resources that use the Chesapeake Bay as a spawning or nursery ground. Because the Chesapeake Bay serves as a nursery area for many coastal migratory fish, annual recruitment data are critical for multi-state management efforts along the Atlantic Coast. Furthermore, the trawl survey serves as a foundation to conduct research on basic biological characteristics of Bay and tributary fishes as well as a platform from which emerging issues may be addressed.

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TABLES

Table 1. Number of potential Chesapeake Bay trawl sites and approximate square miles of sampling strata. '*' indicates areas which are not presently being sampled on a monthly basis with a RSD.

Region	Stratum	Description	No .of Points	Percent of System	% of Total Sampling	Square Miles (NM)
Bottom Bay	001	West. Shoal 12-30'	1740	9.38	7.49	112.33
Region B1	002	East. Shoal 12-30'	863	4.65	3.26	55.72
	003	Central Plain 30-42'	910	4.91	3.44	58.75
	004	Deep Channel ≥42'	386	2.08	1.46	24.92
	S01	West. Shallow 4-12'	216	1.16	0.82	13.94
	S02	East. Shallow 4-12'	58	0.31	0.22	3.74
			4173	22.50	16.69	269.41
Lower Bay	005	West. Shoal 12-30'	1027	5.54	3.88	66.30
Region B2	006	East. Shoal 12-30'	398	2.15	1.50	25.69
	007	Central Plain 30-42'	1756	9.47	6.63	113.37
	008	Deep Channel ≥42'	684	3.69	2.58	44.16
	S05	West. Shallow 4-12'	215	1.16	0.81	13.88
	S06	East. Shallow 4-12'	145	0.78	0.55	9.36
			4225	22.78	15.95	272.77
Upper Bay	009	West. Shoal 12-30'	768	4.14	2.90	49.58
Region B3	010	East. Shoal 12-30'	632	3.41	2.39	40.80
	011	Central Plain 30-42'	2197	11.84	8.30	141.84
	012	Deep Channel ≥42'	844	4.55	3.19	54.49
	S09	West. Shallow 4-12'	209	1.13	0.79	13.49
	S10	East. Shallow 4-12'	216	1.16	0.82	13.94
			4866	26.23	18.39	314.15
Top Bay*	013	West. Shoal 12-30'	404	2.18	1.53	26.08
Region B4	014	East. Shoal 12-30'	1533	8.26	5.79	98.97
	015	Central Plain 30-42'	1315	7.09	4.97	84.90
	016	Deep Channel ≥42'	1273	6.86	4.81	82.18
	S13	West. Shallow 4-12'	164	0.88	0.62	10.59
	S14	East. Shallow 4-12'	597	3.22	2.26	38.54
			5286	28.50	19.98	341.26
Total Bay			18550		71.01	1197.59

Table 2. Number of potential James River trawl sites and approximate square miles of sampling strata. '*' indicates areas which are not presently being sampled with a RSD. The weight factors (No. of Points) have been altered to remove several creeks and rivers.

Region	Stratum	Description	No .of Points	Percent of System	% of Total Sampling	Square Miles (NM)
Bottom James	070	Bottom JA 4-12'	416	16.57	1.57	27.31
Region J1	071	Bottom JA 12-30'	292	11.63	1.10	18.85
	072	Bottom JA 30-42'	68	2.71	0.26	4.39
	073	Bot & Low JA ≥42'	59	2.35	0.22	3.81
	*JH1	Hampton R. 4-12'	5	0.20	0.02	0.32
	*JK1	Chuckatuck R. 4-12'	2	0.08	0.01	0.13
	*JN1	Nansemond R. 4-12'	67	2.67	0.25	4.33
	*JN2	Nansemond R. ≥ 12'	16	0.64	0.06	1.03
			925	36.28	3.49	59.72
Lower James	074	Lower JA 4-12'	389	15.50	1.47	25.11
Region J2	075	Lower JA 12-30'	230	9.16	0.87	14.85
	076	Lower JA 30-42'	25	1.00	0.09	1.61
	*JP1	Pagan R. 4-12'	47	1.87	0.18	3.03
	*JP2	Pagan R. ≥12'	10	0.40	0.04	0.65
	*JW1	Warwick R. 4-12'	50	1.99	0.19	3.23
	*JW2	Warwick R. ≥ 12'	3	0.12	0.01	0.19
			754	30.04	2.85	48.68
Upper James	077	Upper JA 4-12'	178	7.09	0.67	11.49
Region J3	078	Upper JA 12-30'	172	6.85	0.65	11.10
	079	Up & Top JA ≥ 30'	34	1.35	0.13	2.20
	*JS1	Skiffles Cr. 4-12'	25	1.00	0.09	1.61
	*JS2	Skiffles Cr. ≥12'	6	0.24	0.02	0.39
			415	16.53	1.56	26.79
Top James	080	Top JA 4-12'	264	10.52	1.00	17.04
Region J4	081	Top JA 12-30'	152	6.06	0.57	9.81
			416	16.58	1.79	26.86
TOTAL James R.			2510		9.47	162.05

Table 3. Number of potential York River trawl sites and approximate square miles of sampling strata. '*' indicates areas which are not presently being sampled with a RSD.

Region	Stratum	Description	No .of Points	Percent of System	% of Total Sampling	Square Miles (NM)
Bottom York	030	Bottom YK 4-12'	94	12.18	0.36	6.07
Region Y1	031	Bottom YK 12-30'	87	11.27	0.33	5.62
	032	Bottom YK 30-42'	66	8.55	0.25	4.26
	033	Bot & Low YK≥42	71	9.20	0.27	4.58
			318	41.19	1.21	20.53
Lower York	034	Lower YK 4-12'	111	14.38	0.42	7.17
Region Y2	035	Lower YK 12-30'	114	14.77	0.43	7.36
	036	Lower YK 30-42'	28	3.63	0.11	1.81
			253	32.77	0.96	16.33
Upper York	037	Up & Top YK 4-12'	54	6.99	0.20	3.49
Region Y3	038	Upper YK 12-30'	71	9.20	0.27	4.58
	039	Up & Top YK≥30'	29	3.76	0.11	1.87
			154	19.95	0.58	9.94
Top York*	040	Top YK 12-30'	47	6.09	0.18	3.03
Region Y4			47	6.09	0.18	3.03
TOTAL York R.			772		2.93	49.83

Table 4. Number of potential Rappahannock River trawl sites and approximate square miles of sampling strata. '*' indicates areas which are not presently being sampled with a RSD.

Region	Stratum	Description	No .of Points	Percent of System	% of Total Sampling	Square Miles (NM)
Bottom Rappahannock	050	Bottom RA 4-12'	98	7.08	0.37	6.33
Region R1	051	Bottom RA 12-30'	200	14.44	0.76	12.91
	052	Bottom RA 30-42'	66	4.77	0.25	4.26
	053	Bottom RA ≥ 42'	84	6.06	0.32	5.42
			448	32.35	1.70	28.92
Lower Rappahannock	054	Lower RA 4-12'	94	6.79	0.36	6.07
Region R2	055	Lower RA 12-30'	167	12.06	0.63	10.78
	056	Lower RA 30-42'	67	4.84	0.25	4.33
	057	Lower RA ≤ 42'	56	4.04	0.21	3.62
			384	27.73	1.45	24.79
Upper Rappahannock	058	Upper RA 4-12'	233	16.82	0.88	15.04
Region R3	059	Upper RA 12-30'	101	7.29	0.38	6.52
	060	Up & Top RA ≥30'	32	2.31	0.12	2.07
			366	26.43	1.38	23.63
Top Rappahannock	061	Top RA 4-12'	137	9.89	0.52	8.84
Region R4	062	Top RA 12-30'	50	3.61	0.19	3.23
			187	13.50	0.71	12.07
TOTAL Rapp. R.			1385		5.24	89.41
TOTAL SITES			26,474			1498.89

Table 5. Assignment of fixed tributary stations to potential random strata used in the original Bay-River index (BRI) calculations and assignment to strata of the random stratified design surveys. Alternating shaded areas represent the number of points and area used as a weighting factor for the BRI index calculations.

River	River Mile	Depth (ft)	Index Strata	No. Of Points	Sq. Naut. Miles	RSD Strata
James R.	J01	25.0	JA01			071
	J05	20.0	JA01			071
	J13	30.2	JA01			076
	J17	22.0	JA01	**687**	**44.35**	075
	J24	35.0	JA02			079
	J27	28.0	JA02			078
	J35	29.0	JA02			081
	J40	12.0	JA02	364	23.50	081
York R.	Y02	35.0	YK01			032
	Y05	40.0	YK01			032
	Y10	29.9	YK01			035
	Y15	25.0	YK01	**372**	**24.02**	035
	Y20	20.0	YK02			038
	Y25	25.0	YK02			038
	Y30	20.0	YK02			040
	Y35	20.0	YK02			040
	Y40	13.0	YK02	184	11.88	040
Rappahannock R.	R02	60.0	RA01			053
	R10	60.0	RA01			053
	R15	50.0	RA01			057
	R20	50.0	RA01	**283**	**18.27**	057
	R25	29.9	RA02			059
	R30	20.0	RA02			062
	R35	20.0	RA02			062
	R40	12.1	RA02	190	12.26	062

James River: JA01 - Lower ≥ 12ft. JA02 - Upper ≥ 12ft.
York River: YK01 - Lower ≥ 12ft. YK02 - Upper ≥ 12ft.
Rapp. River: RA01 - Lower ≥ 30ft. RA02 - Upper ≥ 12ft.

Table 6. Annual comparisons of substrate (habitat type) from June 1998 – May 2008.

	1998 - 1999		1999 - 2000		2000 - 2001		2001 - 2002		2002 - 2003		2003 - 2004		2004 - 2005		2005 - 2006		2006 - 2007		2007 - 2008	
Substrate Description	% of Stations	Max. Qty.	% of Stations	Max. Qty.	% of Stations	Max. Qty.	% of Stations	Max. Qty.	% of Stations	Max. Qty.	% of Stations	Max. Qty.	% of Stations	Max. Qty.	% of Stations	Max. Qty.	% of Stations	Max. Qty.	% of Stations	Max. Qty.
Artificial	0.68	2.0	3.90	3.0	4.83	2.0	5.68	15.0	5.72	4.0	7.03	7.0	3.27	2.0	1.98	2.0	2.57	3.0	4.17	16.0
Dead man's fingers	7.21	5.0	9.54	4.0	7.42	5.0	8.89	6.0	12.16	16.0	10.29	1.0	3.76	0.5	5.04	24.0	8.11	2.0	9.97	3.0
Detritus	27.55	6.0	40.53	10.0	37.03	4.0	36.91	6.0	50.09	7.0	61.36	10.0	65.69	8.0	54.91	2.0	54.73	4.0	59.80	10.0
Hydroids	38.59	5.0	54.19	4.0	43.20	5.0	57.01	10.5	49.36	5.0	59.15	12.0	72.63	5.0	61.77	4.0	52.70	4.0	60.29	5.0
Sea Squirts (*Molgula spp*.)	20.35	5.0	29.55	12.0	22.54	14.0	27.86	18.0	15.34	5.0	21.08	9.0	25.57	8.0	19.98	14.0	28.51	7.0	30.88	12.0
Seaweeds	14.79	4.0	23.84	10.0	25.67	5.0	29.86	30.0	34.30	18.0	41.75	3.0	33.74	4.0	22.79	2.0	23.78	8.0	23.20	1.0
Shell (oyster, clam, or	18.84	3.0	26.73	4.0	22.00	5.0	29.06	8.0	32.12	4.0	25.98	3.0	21.08	4.0	23.12	12.0	22.70	2.0	21.98	8.0
Sponges	7.96	6.0	9.47	5.0	9.84	5.0	12.33	10.0	14.34	18.0	11.03	3.0	9.48	4.0	7.10	4.0	8.92	4.0	11.11	17.0
Submerged Aquatic	4.35	3.0	8.60	1.0	10.47	2.0	5.04	2.0	6.08	1.0	3.02	0.5	6.70	2.0	2.97	0.5	6.08	1.0	5.15	0.1
Worm Tubes	5.33	1.0	9.54	1.0	10.47	1.0	9.29	1.0	12.34	1.0	14.05	2.0	10.87	1.0	5.45	1.0	9.59	1.0	11.11	0.5
Mud [2]	7.36	---	6.50	---	7.60	---	6.73	---	10.89	---	8.99	---	14.30	---	14.37	---	5.95	---	6.86	---
Sand [2]	10.21	---	0.87	---	1.43	---	1.04	---	0.36	---	0.49	---	0.57	---	0.08	---	0.81	---	8.33	---
Unknown [3]	13.66	---	5.42	---	4.83	---	2.80	---	2.72	---	1.06	---	0.74	---	4.38	---	9.46	---	3.51	---
NUMBER OF TRAWLS:	1,332		1,384		1,118		1,249		1,102		1,224		1,224		1,211		740		1,224	

1. Based on the number of occurrences of a habitat type divided by the total number of trawls.
2. Sand and Mud are used when verification can be confirmed by direct observation.
3. Unknown is used when none of the categories are found in the trawl.

Abundance is estimated relative to the capacity of a commercial test note (internal dimensions 25.7" x 16.6" x 10",
Categories include: 0.5 = < 1/4 bin, 1 = 1/4 bin, 2 = 1/2 bin, 3 =3/4 bin, 4 = full bin, etc.

Table 7. Spatial, temporal, and length criteria used to calculate indices.

	VIMS Trawl Survey - Area / Time / Size Values by Species																					
Species - Age	VIMS	Strata Used									Month											
	SP. CODE	Bay			James		York		Rapp		Size Cut-off Values (mm) - Darkened Areas Represent Index Months											
											January	February	March	April	May	June	July	August	September	October	November	December
American Eel 1+	0060					X		X		X	---	---	---	**>152**	**>152**	**>152**	---	---	---	---	---	---
Atlantic Croaker Y-O-Y	0005				X	X	X	X	X	X	0-100	0-100	0-100	0-110	0-135	0-160	0-180	0-220	0-50	**0-80**	**0-100**	**0-100**
Atlantic Croaker Recruits	0005	X	X	X	X	X	X	X	X	X	0-100	0-100	0-100	0-110	**0-135**	**0-160**	**0-180**	**0-220**	0-50	0-80	0-100	0-100
Atlantic Menhaden	0037				X	X	X	X	X	X					**0-60**	**0-85**						
Bay Anchovy Y-O-Y	0103	X	X	X	X	X	X	X	X	X	0-77	0-80	0-80	0-80	0-80	0-80	**0-44**	**0-51**	**0-56**	**0-61**	**0-65**	**0-70**
Black Seabass Y-O-Y	0002	X	X	X	X						0-110	0-110	0-110	0-110	**0-110**	**0-150**	**0-175**	0-70	0-85	0-100	0-105	0-110
Blue Catfish Y-O-Y	0314					X		X		X	**0-165**	**0-165**	**0-165**	**0-175**	0-225	0-250	0-250	0-115	0-125	0-140	0-150	0-165
Blue Catfish 1+	0314					X		X		X	**>165**	**>165**	**>165**	**>175**	>225	>250	>250	>115	>125	>140	>150	>165
Blue Crab - Age 0	6141 / 6142				X	X	X	X	X	X	0-60	0-60	0-60	0-60	0-60	0-80	0-90	0-35	**0-50**	**0-60**	**0-60**	0-60
Blue Crab - Age 1+	6141 / 6142				X	X	X	X	X	X	>60	>60	>60	>60	>60	>80	>90	**>35**	**>50**	**>60**	>60	>60
Blue Crab - Adult Female	6143	X	X	X	X		X		X		---	---	---	---	---	---	---	**any**	**size**	**crab**	---	---
Channel Catfish Y-O-Y	0040					X		X		X	**0-130**	**0-130**	**0-130**	**0-140**	0-150	0-50	0-80	0-105	0-120	0-130	0-130	0-130
Channel Catfish 1+	0040					X		X		X	**>130**	**>130**	**>130**	**>140**	>150	>50	>80	>105	>120	>130	>130	>130
Northern Puffer Y-O-Y	0050	X	X	X							0-140	0-140	0-140	0-160	0-185	0-50	**0-85**	**0-120**	**0-130**	**0-135**	0-140	0-140
Scup 1+ (?)	0050	X	X								90-170	90-170	90-170	90-170	35-90	**40-100**	**50-125**	**60-145**	**75-160**	85-170	90-170	90-170
Silver Perch Y-O-Y	0213	X	X	X	X	X	X	X	X	X	0-160	0-160	0-160	0-160	0-165	0-170	0-100	0-130	**0-150**	**0-160**	**0-160**	0-160
Spot Y-O-Y	0033	X	X	X	X	X	X	X	X	X	0-200	0-200	0-50	0-75	0-100	0-135	**0-160**	**0-180**	**0-200**	**0-200**	0-200	0-200
Striped Bass Y-O-Y	0031					X		X		X	**0-200**	**0-200**	0-200	0-200	0-50	0-80	0-100	0-120	0-135	0-150	0-175	**0-190**
Summer Flounder Y-O-Y	0003	X	X	X	X		X		X		0-290	0-290	0-60	0-100	0-140	0-170	0-200	0-225	**0-250**	**0-275**	**0-290**	0-290
Weakfish Y-O-Y	0007	X	X	X	X	X	X	X	X	X	0-200	0-200	0-200	0-225	0-240	0-90	0-120	**0-150**	**0-180**	**0-200**	0-200	0-200
White Catfish Y-O-Y	0039					X		X		X	**0-110**	**0-110**	**0-110**	**0-110**	0-120	0-50	0-65	0-80	0-90	0-100	0-110	0-110
White Catfish 1+	0039					X		X		X	**>110**	**>110**	**>110**	**>110**	>120	>50	>65	>80	>90	>100	>110	>110
White Perch Y-O-Y	0032					X		X		X	**0-85**	**0-85**	0-85	0-95	0-35	0-65	0-73	0-80	0-85	0-85	0-85	**0-85**
White Perch 1+	0032					X		X		X	**86-300**	**86-300**	86-300	96-300	36-300	66-300	74-300	81-300	86-300	85-300	**86-300**	**86-300**

Table 8. Summary of samples collected, 1955 - May 2008. Includes sampling from the recent RSD surveys of the tributaries (June 1991 to present).

KEY

Sample Type:
- ALL — All fish species and blue crabs sampled, VIMS code 104
- CRAB — Only blue crabs sampled, VIMS code 102
- FISH — Only fish species sampled, VIMS code 090

System:
- CL — Lower Chesapeake Bay (Virginia Portion)
- JA — James River
- PO — Potomac River
- RA — Rappahannock River
- YK — York River
- ZZ — includes: Atlantic Ocean (AT) - 1971, 78-79; Piankatank R. (PK) - 1970-71, 98-00; Mobjack Bay (MB) - 1970-73, 98-01; Pocomoke Sound (CP) -1973-81, 98-01; Great Wicomico R. (GW) - 1998-00.

Vessel:
- BR — W.K. Brooks
- FH — Fish Hawk
- JS — Captain John Smith, J1 prior to 1986.
- LA — Langley
- PA — Pathfinder
- RE — Restless
- OT — Includes: Aquarius (AQ) - 1978; Investigator (IN) - 1970; Judith Ann (JA) - 1981; Langley II (LN) - 1985,2001; Sally Jean (SJ) - 1981; Outboard Skiff (SK) - 1970-71; Three Daughters (TD) - 1978; Virginia Lee (VL) - 1955-57; Edith May (EM) - 1984.

Gear Code:

30' Gears
- 010 — Unlined, no tickler chain, 30' bridle, 48"x22" otter board doors, U_N_3B_SW
- 033 — Lined, no tickler chain, 30' bridle, 48"x22" doors, L_N_3B_SW
- 043 — Unlined, tickler chain, 30' bridle, 54"x24" doors, U_T_3B_LW
- 068 — Lined, tickler chain, 30' bridle, 54"x24" otter board doors, L_T_3B_LW
- 070 — Lined, tickler chain, 60' bridle, 54"x24" doors, L_T_6B_LW
- 108 — Lined, tickler chain, 60' bridle, metal china-v doors, L_T_6B_CV

OT includes 3 configurations of 16 foot nets.
- 035: Lined, no tickler chain, 23' bridle, 24"x12" otter board doors, 16L_N_2B_SW. Main Gear used
- 009: Unlined, no tickler chain, 16U_N_2B_SW. 19 tows in 1972.
- 067: Lined, w/ tickler chain, 16L_T_2B_SW. 60 samples on the Elizabeth River in 1982-83.

Station Type:
- F - Fixed
- R - Random

Tow Type:
- OT is tow duration in minutes for those not listed.
- DIS is distance, always 0.25 nautical miles. Equates well to 5 minute duration.

All Codes found on table from Wojcik and Van Engel, 1988. Appendices A – C

Table 8 (cont.) Sample collection history of the VIMS Trawl Survey, 1955 – May 2008. Codes are on previous page.

YR	TOT	SAMPLE TYPE			MONTH												WATER SYSTEM					
		ALL	CRAB	FISH	J	F	M	A	M	J	J	A	S	O	N	D	CL	JA	PO	RA	YK	ZZ
1955	31	0	0	31	0	3	1	3	1	5	14	1	3	0	0	0	6	0	0	0	25	0
1956	135	103	0	32	0	0	0	16	17	0	17	20	17	16	16	16	43	0	0	0	92	0
1957	141	113	0	28	12	16	16	0	12	0	4	16	17	16	16	16	46	0	0	0	95	0
1958	192	167	0	25	16	16	13	16	19	16	15	17	16	16	16	16	56	0	0	0	136	0
1959	117	86	2	29	0	0	0	14	3	16	19	16	16	16	17	0	32	0	0	0	85	0
1960	57	42	0	15	0	0	0	0	16	14	14	13	0	0	0	0	19	0	0	0	38	0
1961	89	19	16	54	6	0	0	4	10	12	8	8	11	12	10	8	15	0	0	0	74	0
1962	116	6	35	75	8	8	8	5	12	19	8	8	11	11	11	7	18	0	0	17	81	0
1963	142	25	45	72	6	8	9	13	16	18	14	9	19	13	9	8	19	0	0	22	101	0
1964	190	104	36	50	23	9	9	12	20	22	18	15	14	19	14	15	24	62	0	0	104	0
1965	189	106	5	78	22	13	17	14	14	14	14	19	14	15	12	21	1	71	0	23	94	0
1966	214	138	3	73	14	21	25	16	17	17	17	23	13	18	16	17	21	70	0	9	114	0
1967	259	195	2	62	15	17	31	17	17	24	23	23	23	23	23	23	23	67	0	61	108	0
1968	262	215	2	45	14	16	16	23	23	23	21	31	23	23	23	26	23	70	0	65	104	0
1969	286	281	1	4	23	23	24	24	24	24	24	24	24	24	24	24	23	72	0	83	108	0
1970	359	276	1	82	17	24	24	24	24	24	51	24	51	23	51	22	23	70	0	80	105	81
1971	804	346	57	401	51	18	51	55	61	63	103	82	74	82	82	82	24	80	0	96	449	155
1972	851	168	97	586	73	73	73	56	56	75	71	85	43	98	94	54	14	86	0	95	545	111
1973	871	179	0	692	54	53	11	56	80	202	91	91	105	105	23	0	88	67	0	80	591	45
1974	748	175	0	573	156	137	75	0	27	26	166	62	55	26	18	0	138	147	73	174	216	0
1975	795	435	7	353	194	128	16	0	18	18	349	18	18	18	18	0	162	148	60	194	231	0
1976	1141	308	0	833	184	141	23	40	40	40	525	40	40	36	32	0	174	340	60	318	249	0
1977	876	182	0	694	0	0	182	0	26	26	493	71	26	26	26	0	113	243	8	284	228	0
1978	1130	208	0	922	94	214	79	0	26	90	396	66	26	26	26	87	171	366	78	220	285	10
1979	810	321	0	489	282	70	124	0	36	41	47	46	37	44	44	39	60	267	63	159	260	1
1980	559	248	0	311	28	48	46	18	49	51	50	50	58	52	52	57	129	145	0	115	170	0
1981	486	243	1	242	41	34	52	17	52	46	52	24	39	42	38	49	52	146	18	97	173	0
1982	580	261	0	319	11	67	80	54	53	40	40	45	50	46	46	48	43	180	37	140	180	0
1983	482	295	0	187	32	54	14	15	40	39	39	38	38	65	50	58	0	162	19	118	183	0
1984	475	261	1	213	19	13	38	45	50	49	47	46	37	49	49	33	0	212	21	95	147	0
1985	335	191	0	144	36	26	26	26	35	12	38	39	27	45	0	25	0	120	17	75	123	0
1986	374	374	0	0	22	24	25	24	37	35	37	37	37	37	36	23	0	135	0	117	122	0
1987	334	334	0	0	23	24	23	24	36	37	33	34	32	34	34	0	0	108	0	108	118	0
1988	889	802	87	0	69	69	62	48	82	82	82	82	82	82	80	69	576	97	0	105	111	0
1989	840	749	91	0	61	61	61	66	76	76	76	76	76	76	76	59	479	108	0	124	129	0
1990	827	739	88	0	61	61	61	61	76	76	77	75	76	69	76	58	473	108	0	119	127	0
1991	930	840	90	0	61	25	61	61	73	94	95	95	97	97	97	74	411	108	0	120	291	0
1992	982	891	91	0	79	47	79	79	97	88	88	88	89	88	88	72	404	110	0	124	344	0
1993	915	824	91	0	40	73	40	71	88	89	88	88	88	88	87	75	370	110	0	126	309	0
1994	911	820	91	0	40	73	40	73	88	88	88	88	88	88	88	69	368	110	0	124	309	0
1995	993	980	13	0	40	73	40	73	92	88	88	88	105	105	99	102	411	96	0	201	285	0
1996	1176	1176	0	0	52	91	71	106	106	107	108	108	107	108	107	105	435	228	0	258	255	0
1997	1220	1220	0	0	68	105	66	98	110	111	111	112	111	112	111	105	425	265	0	264	266	0
1998	1262	1262	0	0	66	105	66	105	111	111	128	59	138	124	130	119	388	265	0	256	264	89
1999	1382	1382	0	0	79	122	80	122	120	118	119	118	122	124	131	127	402	264	0	264	265	187
2000	1367	1367	0	0	52	129	85	101	158	111	128	125	121	141	111	105	433	250	17	266	265	136
2001	1122	1122	0	0	30	30	30	75	112	144	111	112	135	136	111	96	384	230	35	230	230	13
2002	1090	1090	0	0	66	90	66	90	96	106	96	97	95	96	96	96	288	264	0	264	264	10
2003	1191	1191	0	0	66	96	66	96	96	111	111	111	111	111	111	105	399	264	0	264	264	0
2004	1224	1224	0	0	66	105	66	105	111	111	111	111	111	111	111	105	432	264	0	264	264	0
2005	1211	1211	0	0	66	105	66	105	111	111	111	111	113	111	111	90	419	264	0	264	264	0
2006	1193	1193	0	0	66	105	66	105	111	111	111	111	113	111	78	105	423	242	0	264	264	0
2007	1224	1224	0	0	66	105	66	105	111	111	111	111	111	111	111	105	432	264	0	264	264	0
2008	453	453	0	0	66	105	66	105	111	0	0	0	0	0	0	0	123	110	0	110	110	1
TOT	36832	28165	953	7714	2736	3073	2435	2481	3103	3182	4896	3107	3103	3165	2936	2615	10035	7455	506	7120	10878	839

YR	RESEARCH VESSEL							GEAR CODE							STAT. TYPE		TOW DURATION/DISTANCE				
	BR	FH	JS	LA	PA	RE	ZZ	010	033	043	068	070	108	OT	F	R	5	7.5	15	OT	DIS
1955	0	0	0	0	0	0	31	31	0	0	0	0	0	0	31	0	0	12	17	2	0
1956	0	0	0	0	0	0	135	135	0	0	0	0	0	0	135	0	0	6	127	2	0
1957	0	0	0	0	85	0	56	141	0	0	0	0	0	0	141	0	0	44	97	0	0
1958	0	0	0	0	192	0	0	192	0	0	0	0	0	0	192	0	0	58	134	0	0
1959	0	0	0	0	117	0	0	117	0	0	0	0	0	0	117	0	0	34	83	0	0
1960	0	0	0	0	57	0	0	57	0	0	0	0	0	0	57	0	0	10	44	3	0
1961	0	0	0	0	89	0	0	89	0	0	0	0	0	0	89	0	0	26	63	0	0
1962	0	0	0	22	94	0	0	116	0	0	0	0	0	0	116	0	0	31	84	1	0
1963	0	0	0	63	79	0	0	142	0	0	0	0	0	0	142	0	0	37	102	3	0
1964	0	0	0	75	115	0	0	190	0	0	0	0	0	0	190	0	1	36	149	4	0
1965	0	0	0	44	145	0	0	189	0	0	0	0	0	0	189	0	0	38	145	6	0
1966	0	0	0	184	30	0	0	214	0	0	0	0	0	0	214	0	0	51	163	0	0
1967	0	0	0	16	243	0	0	259	0	0	0	0	0	0	259	0	0	58	192	9	0
1968	0	0	0	4	258	0	0	259	3	0	0	0	0	0	262	0	10	66	180	6	0
1969	0	0	0	0	286	0	0	286	0	0	0	0	0	0	286	0	1	86	189	10	0
1970	14	0	0	0	314	0	31	305	0	0	0	0	0	54	359	0	3	173	177	6	0
1971	154	0	0	50	358	234	8	372	0	32	0	0	0	400	572	232	440	172	189	3	0
1972	73	0	0	154	193	431	0	246	0	101	0	0	0	504	506	345	657	104	89	1	0
1973	126	0	0	64	237	444	0	0	122	179	0	0	0	570	304	567	751	0	0	120	0
1974	0	0	0	568	105	75	0	0	498	175	0	0	0	75	478	270	257	0	0	38	453
1975	117	0	0	429	176	73	0	0	535	126	0	0	0	134	126	669	471	0	0	2	322
1976	230	0	6	466	262	177	0	0	426	308	0	0	0	407	308	833	816	0	0	0	325
1977	172	0	23	269	130	282	0	0	240	182	0	0	0	454	182	694	771	0	0	0	105
1978	22	0	73	544	153	179	159	0	583	181	0	0	0	366	181	949	551	0	16	2	561
1979	0	0	43	371	333	63	0	2	461	0	284	0	0	63	285	525	485	0	0	2	323
1980	0	0	367	0	192	0	0	0	140	0	0	419	0	0	362	197	558	0	0	1	0
1981	0	0	424	0	16	0	46	0	0	0	0	486	0	0	295	191	478	0	0	8	0
1982	0	0	580	0	0	0	0	0	0	0	0	538	0	42	364	216	577	0	0	3	0
1983	0	0	482	0	0	0	0	0	0	0	0	465	0	17	367	115	478	0	0	4	0
1984	0	0	461	0	0	0	14	0	3	0	0	472	0	0	475	0	471	0	0	4	0
1985	0	0	285	0	0	0	50	0	0	0	0	335	0	0	335	0	333	0	0	2	0
1986	0	0	374	0	0	0	0	0	0	0	0	374	0	0	374	0	374	0	0	0	0
1987	0	0	334	0	0	0	0	0	0	0	0	334	0	0	334	0	333	0	0	0	1
1988	0	0	889	0	0	0	0	0	0	0	0	889	0	0	313	576	885	0	0	0	4
1989	0	0	840	0	0	0	0	0	0	0	0	840	0	0	361	479	840	0	0	0	0
1990	0	279	548	0	0	0	0	0	0	0	0	827	0	0	354	473	826	0	0	0	1
1991	0	930	0	0	0	0	0	0	0	0	0	0	930	0	357	573	928	0	0	1	1
1992	0	982	0	0	0	0	0	0	0	0	0	0	982	0	361	621	975	0	0	7	0
1993	0	915	0	0	0	0	0	0	0	0	0	0	915	0	365	550	914	0	0	1	0
1994	0	911	0	0	0	0	0	0	0	0	0	0	911	0	363	548	906	0	0	5	0
1995	0	993	0	0	0	0	0	0	0	0	0	0	993	0	314	679	984	0	0	9	0
1996	0	1176	0	0	0	0	0	0	0	0	0	0	1176	0	279	897	1168	0	0	6	2
1997	0	1220	0	0	0	0	0	0	0	0	0	0	1220	0	302	918	1217	0	0	3	0
1998	0	1262	0	0	0	0	0	0	0	0	0	0	1262	0	322	940	1261	0	0	1	0
1999	0	1382	0	0	0	0	0	0	0	0	0	0	1382	0	363	1019	1380	0	0	2	0
2000	0	1367	0	0	0	0	0	0	0	0	0	0	1367	0	363	1004	1367	0	0	0	0
2001	0	1017	0	0	0	0	105	0	0	0	0	0	1122	0	277	845	1119	0	0	1	2
2002	0	1090	0	0	0	0	0	0	0	0	0	0	1090	0	300	790	1089	0	0	1	0
2003	0	1191	0	0	0	0	0	0	0	0	0	0	1191	0	300	891	1191	0	0	0	0
2004	0	1224	0	0	0	0	0	0	0	0	0	0	1224	0	300	924	1224	0	0	0	0
2005	0	1211	0	0	0	0	0	0	0	0	0	0	1211	0	300	911	1211	0	0	0	0
2006	0	1193	0	0	0	0	0	0	0	0	0	0	1193	0	292	901	453	0	0	0	0
2007	0	1224	0	0	0	0	0	0	0	0	0	0	1224	0	300	924	1224	0	0	0	0
2008	0	453	0	0	0	0	0	0	0	0	0	0	453	0	125	328	453	0	0	0	0
TOT	908	20020	5729	3323	4259	1958	635	3342	3011	1284	284	5979	19846	3086	15238	21594	30431	1042	2240	279	2100

Table 9. VIMS Trawl Survey pooled catch for June 2007 to May 2008. Number of trawls = 1224.

Adjusted Percent of Catch Excludes Bay Anchovy and Hogchoker

Species	Number of Fish (All)	Frequency	Percent of Catch	Catch Per Trawl	Adjusted Percent of Catch	Number of Fish YOY	Average Length (mm)	Standard Error (length)	Minimum Length (mm)	Maximum Length (mm)
bay anchovy	289,867	1043	53.87	236.82	.	232,984	55	0.07	15	104
hogchoker	101,522	708	18.87	82.94	.	44,601	77	0.2	17	191
Atlantic croaker	48,060	832	8.93	39.26	32.76	38,010	115	0.47	10	400
spot	24,423	701	4.54	19.95	16.65	20,211	131	0.23	13	252
weakfish	15,386	545	2.86	12.57	10.49	13,485	110	0.49	13	340
white perch	10,562	282	1.96	8.63	7.2	1,819	138	0.61	21	279
blue catfish	6,192	188	1.15	5.06	4.22	1,789	233	1.09	46	692
northern searobin	3,325	235	0.62	2.72	2.27	3,294	93	0.51	13	221
silver perch	3,271	280	0.61	2.67	2.23	2,096	139	0.55	25	215
kingfish spp	2,978	387	0.55	2.43	2.03	2,629	110	1.06	12	339
blackcheek tonguefish	2,873	440	0.53	2.35	1.96	1,476	105	0.76	34	193
striped anchovy	2,354	155	0.44	1.92	1.6	2,313	83	0.52	25	125
spotted hake	2,062	220	0.38	1.68	1.41	2,060	138	0.83	41	285
blueback herring	1,856	81	0.34	1.52	1.26	1,783	80	0.41	39	223
Atlantic menhaden	1,357	238	0.25	1.11	0.92	1,030	64	1.63	25	302
summer flounder	1,338	419	0.25	1.09	0.91	840	237	2.69	20	610
smallmouth flounder	1,251	175	0.23	1.02	0.85	1,087	88	0.48	37	154
scup	1,213	135	0.23	0.99	0.83	1,162	96	0.71	45	169
gizzard shad	636	111	0.12	0.52	0.43	513	178	3.07	89	435
striped bass	625	123	0.12	0.51	0.43	550	103	4.8	18	835
oyster toadfish	476	153	0.09	0.39	0.32	.	179	3.5	36	378
harvestfish	406	106	0.08	0.33	0.28	356	87	1.81	14	169
American shad	331	79	0.06	0.27	0.23	331	104	0.89	55	154
black seabass	286	112	0.05	0.23	0.19	227	108	2.29	46	253
white catfish	262	96	0.05	0.21	0.18	8	245	4.29	55	523
alewife	234	72	0.04	0.19	0.16	231	111	1.41	69	237
Atlantic spadefish	211	78	0.04	0.17	0.14	.	93	1.94	22	182
naked goby	196	80	0.04	0.16	0.13	.	41	0.65	23	63
butterfish	163	63	0.03	0.13	0.11	106	104	3.71	25	183
windowpane	149	72	0.03	0.12	0.1	116	146	2.87	56	261
northern pipefish	136	96	0.03	0.11	0.09	.	140	3.29	45	265
hickory shad	125	45	0.02	0.1	0.09	.	105	3.44	54	308
clearnose skate	122	45	0.02	0.1	0.08	.	412	5.08	137	523
American eel	108	66	0.02	0.09	0.07	.	300	10.04	57	573
channel catfish	91	23	0.02	0.07	0.06	3	252	5.63	88	363
inshore lizardfish	87	54	0.02	0.07	0.06	52	177	5.5	61	311
bluefish	81	38	0.02	0.07	0.06	.	190	5.3	78	396
Atlantic thread herring	77	28	0.01	0.06	0.05	.	111	5.83	43	196
lined seahorse	72	52	0.01	0.06	0.05	.	71	2.45	25	125
northern puffer	61	42	0.01	0.05	0.04	37	122	6.22	18	223
striped searobin	55	37	0.01	0.04	0.04	.	85	5.7	31	231
feather blenny	45	27	0.01	0.04	0.03	.	67	2.76	31	107
Atlantic silverside	39	22	0.01	0.03	0.03	39	87	1.69	62	106
seaboard goby	36	28	0.01	0.03	0.02	.	39	1.2	25	54
black drum	34	19	0.01	0.03	0.02	.	237	30.77	156	1240
star drum	34	5	0.01	0.03	0.02	.	59	3.15	26	105
red hake	28	8	0.01	0.02	0.02	.	154	6.2	102	220
banded drum	24	20	0	0.02	0.02	.	72	12.18	16	228
spotted seatrout	22	17	0	0.02	0.01	.	179	16.15	21	308
spiny dogfish	20	11	0	0.02	0.01	.	741	11.91	646	850
Atlantic cutlassfish	19	15	0	0.02	0.01	.	370	35.98	137	660
pigfish	19	9	0	0.02	0.01	.	160	5.56	123	198
smooth butterfly ray	18	11	0	0.01	0.01	.	575	37.96	354	910
bluntnose stingray	17	14	0	0.01	0.01	.	411	22.12	235	566
common carp	16	3	0	0.01	0.01	.	511	16.98	424	668
skilletfish	15	15	0	0.01	0.01	.	51	3.22	19	69
spiny butterfly ray	14	11	0	0.01	0.01	.	640	72.41	429	1270
longnose gar	14	8	0	0.01	0.01	.	699	29.66	398	854

Table 9 (cont.)

Adjusted Percent of Catch Excludes Bay Anchovy and Hogchoker

Species	Number of Fish (All)	Frequency	Percent of Catch	Catch Per Trawl	Adjusted Percent of Catch	Number of Fish YOY	Average Length (mm)	Standard Error (length)	Minimum Length (mm)	Maximum Length (mm)
green goby	13	13	0	0.01	0.01	.	45	2.79	16	54
Atlantic moonfish	13	9	0	0.01	0.01	.	96	2.82	75	109
Atlantic stingray	12	12	0	0.01	0.01	.	285	25.08	164	405
sheepshead	11	8	0	0.01	0.01	.	237	63.97	100	593
winter flounder	11	7	0	0.01	0.01	.	47	3.04	39	73
threadfin shad	11	6	0	0.01	0.01	.	105	3.49	85	119
red drum	10	10	0	0.01	0.01	.	76	7.3	45	113
striped cusk-eel	10	3	0	0.01	0.01	.	132	7.63	79	166
sea lamprey	8	6	0	0.01	0.01	.	172	4.34	155	189
blue runner	7	4	0	0.01	0	.	153	9.12	120	179
crested blenny	7	2	0	0.01	0	.	50	5.82	34	78
silver seatrout	6	2	0	0	0	.	126	10.19	99	169
Atlantic herring	5	4	0	0	0	.	83	39.4	43	241
spotfin mojarra	5	4	0	0	0	.	80	8.77	47	99
bluespotted cornetfish	4	4	0	0	0	.	218	45.07	103	290
striped blenny	4	4	0	0	0	.	59	7.32	46	74
lookdown	4	4	0	0	0	.	105	11.42	81	130
brown bullhead	4	3	0	0	0	.	131	32.06	77	210
striped burrfish	4	2	0	0	0	.	193	13.82	158	224
smooth dogfish	3	3	0	0	0	.	528	10.5	507	539
Spanish mackerel	3	2	0	0	0	.	91	9.94	79	111
cownose ray	3	2	0	0	0	.	688	140.25	462	945
tautog	2	2	0	0	0	.	355	23.5	331	378
bluegill	2	2	0	0	0	.	75	39	36	114
bullnose ray	2	2	0	0	0	.	372	24.5	347	396
northern stargazer	2	2	0	0	0	.	179	10	169	189
gray snapper	2	2	0	0	0	.	85	10.5	74	95
silver hake	1	1	0	0	0	.	172	.	172	172
cobia	1	1	0	0	0	.	1000	.	1000	1000
mummichog	1	1	0	0	0	.	55	.	55	55
threespine stickleback	1	1	0	0	0	.	23	.	23	23
dusky pipefish	1	1	0	0	0	.	121	.	121	121
pumpkinseed	1	1	0	0	0	.	61	.	61	61
inland silverside	1	1	0	0	0	.	53	.	53	53
eastern mudminnow	1	1	0	0	0	.	66	.	66	66
fringed flounder	1	1	0	0	0	.	128	.	128	128
orange filefish	1	1	0	0	0	.	112	.	112	112
rock seabass	1	1	0	0	0	.	210	.	210	210
All Species Combined	525,473									

Table 10. American eel indices (1988–2007).

Year	Random Stratified Index (RSI)				Original Index	
	Geo. Mean	95% C.I.'s	C.V.	N	River Only (RO)	N
1988	1.26	0.48 - 2.46	26.08	18	2.30	18
1989	7.93	4.62 - 13.18	10.57	31	8.82	31
1990	4.85	3.25 - 7.04	9.02	30	6.67	31
1991	2.07	0.81 - 4.21	23.58	37	2.12	31
1992	7.41	5.62 - 9.69	5.62	46	4.01	31
1993	3.19	2.21 - 4.47	9.30	43	3.68	31
1994	2.22	1.11 - 3.90	18.02	43	2.48	31
1995	2.35	1.78 - 3.03	7.72	45	2.44	33
1996	2.57	1.77 - 3.59	9.94	84	2.81	33
1997	2.29	1.11 - 4.13	18.69	90	1.37	39
1998	2.00	1.00 - 3.51	18.49	90	2.30	39
1999	1.25	0.58 - 2.19	21.67	90	1.14	39
2000	1.42	0.75 - 2.35	18.42	90	1.15	38
2001	0.79	0.18 - 1.72	35.92	90	0.46	39
2002	0.80	0.30 - 1.52	28.11	90	0.93	39
2003	0.79	0.22 - 1.61	32.68	90	0.60	39
2004	0.43	0.21 - 0.68	22.95	90	0.50	39
2005	0.35	0.21 - 0.51	18.66	90	0.47	39
2006	0.15	0.00 - 0.32	49.69	90	0.06	39
2007	0.22	0.07 - 0.38	31.92	90	0.14	39

Table 11. Fall Atlantic croaker indices (1988–2007).

Year	Random Stratified Index (RSI)				Original Index	
	Geo. Mean	95% C.I.'s	C.V.	N	River Only (RO)	N
1988	7.46 (9.35)*	5.76 - 14.84	9.33	65	9.05	65
1989	45.95 (60.27)*	35.47 - 101.95	6.36	65	64.78	65
1990	9.41 (11.68)*	7.8 - 17.28	7.42	60	13.15	60
1991	5.71	3.94 - 8.10	8.02	132	9.57	63
1992	10.54	6.95 - 15.75	7.62	112	14.60	67
1993	4.54	2.84 - 7.00	10.72	113	5.42	69
1994	10.45	6.70 - 16.04	8.15	112	13.48	67
1995	12.75	9.61 - 16.81	4.94	180	11.79	69
1996	32.46	20.05 - 52.17	6.60	191	31.06	69
1997	7.94	5.08 - 12.12	8.77	199	10.41	75
1998	24.15	16.74 - 34.65	5.41	199	21.26	75
1999	11.27	7.25 - 17.23	7.90	198	14.33	75
2000	7.68	5.50 - 10.60	6.70	197	5.96	74
2001	5.73	4.05 - 7.96	7.54	198	7.05	75
2002	6.84	4.48 - 10.20	8.68	198	10.35	75
2003	100.36	68.35 - 147.16	4.11	198	96.17	75
2004	12.29	7.56 - 19.63	8.51	198	24.18	75
2005	8.68	5.57 - 13.24	8.52	198	8.10	75
2006	9.58	5.56 - 16.07	10.13	176	18.88	67
2007	8.99	6.04 - 13.17	7.60	198	10.73	75

* Converted index shown in parentheses

Table 12. Spring Atlantic croaker indices (1988–2007).

Year	Random Stratified Index (RSI)				Original Index			
	Geo. Mean	95% C.I.'s	C.V.	N	Bay & River (BRI)	N	River Only (RO)	N
1988	0.36 (0.32)*	0.21 - 0.44	16.05	234	0.38	234	2.22	84
1989	0.65 (0.6)*	0.38 - 0.85	15.63	252	0.78	252	4.63	84
1990	0.48 (0.43)*	0.23 - 0.67	20.56	252	0.52	252	2.98	85
1991	4.41	3.08 - 6.18	8.36	307	4.35	238	12.87	83
1992	1.28	0.87 - 1.78	12.10	309	1.34	240	10.26	84
1993	2.17	1.5 - 3.02	10.34	301	2.21	240	19.40	84
1994	0.90	0.6 - 1.26	13.54	300	0.95	240	2.98	84
1995	1.06	0.77 - 1.39	10.40	306	0.93	246	5.55	90
1996	0.19	0.11 - 0.28	19.63	405	0.16	242	0.36	88
1997	1.47	1.15 - 1.85	7.78	419	0.87	255	7.78	100
1998	1.19	0.95 - 1.47	7.51	374	0.48	214	6.21	96
1999	1.50	1.05 - 2.05	10.83	397	1.28	232	4.08	100
2000	0.60	0.42 - 0.80	12.68	413	0.44	245	1.39	97
2001	0.37	0.25 - 0.49	14.38	420	0.32	256	1.18	100
2002	1.59	1.07 - 2.22	11.59	361	1.11	197	4.80	100
2003	0.49	0.28 - 0.74	19.19	405	0.52	241	0.28	100
2004	0.96	0.73 - 1.22	9.34	420	0.70	255	4.42	99
2005	0.47	0.35 - 0.59	10.46	420	0.31	256	1.85	100
2006	1.27	1.00 - 1.59	7.90	420	0.77	256	3.92	100
2007	1.04	0.76 - 1.37	10.34	420	0.76	256	3.05	100

* Converted index shown in parentheses

Table 13. Atlantic menhaden indices (1988–2007).

Year	Random Stratified Index (RSI)			
	Geo. Mean	95% C.I.'s	C.V.	N
1988	0.00	0	.	42
1989	0.13	-0.45	81.54	42
1990	0.08	0.02 - 0.15	35.60	42
1991	0.04	-0.01-0.08	58.48	63
1992	0.01	-0.04	100	81
1993	0	0	.	73
1994	0.04	0.00 - 0.08	43.85	72
1995	0	0	.	74
1996	0.05	-0.01 - 0.10	57.4	125
1997	0.01	0.00 - 0.02	65.92	132
1998	0.18	0.07 - 0.31	30.81	132
1999	0.01	-0.01 - 0.03	100	133
2000	0.03	-0.02 - 0.07	83.44	133
2001	0.05	0.04 - 0.07	9.81	132
2002	0.07	-0.02 - 0.16	66.96	132
2003	0.17	0.06 - 0.28	30.58	132
2004	0.13	-0.03 - 0.33	64.16	132
2005	0.30	0.08 - 0.58	36.16	132
2006	0.03	-0.02 - 0.08	74.17	132
2007	0.04	0.00 - 0.10	71.05	132

Table 14. Bay anchovy indices (1988–2007).

Year	Random Stratified Index (RSI)				Original Index			
	Geo. Mean	95% C.I.'s	C.V.	N	Bay & River (BRI)	N	River Only (RO)	N
1988	18.25	12.17 - 27.15	6.42	346	18.06	346	32.66	128
1989	52.47	36.27 - 75.71	4.54	374	51.59	374	22.74	128
1990	6.79	4.41 - 10.22	8.89	369	6.65	369	8.78	124
1991	19.86	13.39 - 29.23	6.11	491	22.83	350	33.41	125
1992	35.06	23.92 - 51.17	5.15	448	40.79	355	14.53	128
1993	36.83	24.72 - 54.65	5.31	449	42.71	360	28.93	132
1994	13.10	8.93 - 19.02	6.63	444	14.36	354	19.86	130
1995	13.26	9.48 - 18.41	5.8	540	18.52	362	18.57	138
1996	15.31	11.20 - 20.82	5.21	607	16.91	363	5.11	135
1997	18.96	13.63 - 26.23	5.19	625	17.33	378	12.64	150
1998	30.26	20.75 - 43.93	5.27	579	30.47	336	9.7	146
1999	15.47	11.20 - 21.22	5.35	606	14.38	360	21.26	150
2000	36.58	26.69 - 49.99	4.21	619	40.36	369	16.24	147
2001	9.55	6.93 - 13.04	6.06	627	9.23	377	4.56	150
2002	5.51	3.58 - 8.24	9.36	540	4.09	294	9.3	150
2003	18.03	13.17 - 24.56	5.01	624	20.65	378	3.41	150
2004	23.06	16.71 - 31.70	4.82	624	21.45	377	7.02	149
2005	22.27	16.01 - 30.85	4.98	613	21.26	367	8.43	150
2006	19.31	14.00 - 26.50	5.03	592	16.99	360	10.59	142
2007	23.76	17.33 - 32.44	4.69	624	21.15	378	10.27	150

Table 15. Black sea bass indices (1988–2006).

Year	Random Stratified Index (RSI)				Original Index			
	Geo. Mean	95% C.I.'s	C.V.	N	Bay & River (BRI)	N	River Only (RO)	N
1988	0.84	0.59-1.13	11.89	138	0.83	138	1.04	12
1989	2.36	1.7-3.17	8.93	138	2.36	138	1.52	12
1990	1.12	0.78-1.53	11.63	128	1.12	128	0.50	12
1991	1.28	0.91-1.72	10.76	129	1.29	129	2.35	12
1992	0.22	0.13-0.32	18.86	129	0.22	129	0.19	12
1993	1.05	0.74-1.42	11.46	129	1.04	129	0.76	12
1994	1.06	0.74-1.45	11.85	129	1.06	129	0.60	12
1995	0.50	0.33-0.69	14.47	151	0.54	127	0.62	12
1996	0.36	0.22-0.52	17.99	152	0.35	128	0.38	12
1997	0.46	0.31-0.63	14.63	153	0.47	129	0.23	12
1998	0.57	0.35-0.82	16.40	135	0.59	111	0.32	12
1999	0.58	0.41-0.77	12.22	146	0.60	122	0.48	12
2000	0.74	0.50-1.02	13.39	153	0.78	129	0.93	12
2001	1.29	0.85-1.84	12.89	108	1.33	84	1.31	12
2002	0.64	0.41-0.90	15.16	138	0.69	114	0.57	12
2003	0.12	0.06-0.18	25.11	153	0.11	129	0.12	12
2004	0.06	0.02-0.10	34.69	153	0.05	129	0.06	12
2005	0.19	0.12-0.26	17.66	153	0.20	129	0.06	12
2006	0.44	0.3-0.60	14.14	153	0.48	129	0.06	12

Table 16. Blue catfish juvenile indices (1988–2007).

Year	Random Stratified Index (RSI) Geo. Mean	95% C.I.'s	C.V.	N	Original Index River Only (RO)	N
1988	0.00	0.00 - 0.01	100.00	52	0.01	52
1989	0.43	0.00 - 1.24	61.91	51	0.25	52
1990	0.14	0.02 - 0.28	42.14	52	0.29	52
1991	0.37	0.25 - 0.50	14.11	72	0.19	52
1992	0.33	0.15 - 0.54	24.87	68	0.26	52
1993	0.18	0.07 - 0.30	28.51	68	0.45	52
1994	0.16	0.03 - 0.32	40.81	68	0.38	52
1995	0.64	0.34 - 1.00	20.18	109	0.91	52
1996	0.92	0.40 - 1.63	24.21	120	1.24	53
1997	2.40	1.55 - 3.54	11.81	120	2.33	52
1998	0.31	0.14 - 0.52	26.57	120	0.54	52
1999	0.14	0.04 - 0.25	36.47	114	0.30	52
2000	0.22	0.00 - 0.60	66.93	120	0.10	52
2001	0.02	0.00 - 0.04	67.15	120	0.02	52
2002	0.61	0.14 - 1.28	36.48	120	0.50	52
2003	1.33	0.75 - 2.10	16.88	120	2.50	52
2004	1.82	0.83 - 3.35	20.95	120	3.34	52
2005	2.59	1.53 - 4.10	13.75	120	3.88	52
2006	1.52	0.74 - 2.65	19.95	120	3.34	52
2007	0.60	0.18 - 1.17	32.32	120	0.66	52

Table 17. Blue catfish Age 1+ indices (1988–2007).

Year	Random Stratified Index (RSI) Geo. Mean	95% C.I.'s	C.V.	N	Original Index River Only (RO)	N
1988	0.02	0.00 - 0.05	100.00	52	0.05	52
1989	0.10	0.00 - 0.28	82.29	51	0.10	52
1990	0.26	0.10 - 0.45	29.18	52	0.61	52
1991	0.80	0.48 - 1.19	16.69	72	0.42	52
1992	1.09	0.65 - 1.66	16.17	68	0.84	52
1993	0.47	0.06 - 1.03	42.59	68	0.57	52
1994	0.50	0.15 - 0.95	32.59	68	1.03	52
1995	0.48	0.14 - 0.93	33.56	109	0.62	52
1996	1.38	0.62 - 2.49	22.11	120	2.32	53
1997	3.85	2.41 - 5.89	11.17	120	4.41	52
1998	1.99	0.95 - 3.59	19.57	120	3.34	52
1999	1.06	0.54 - 1.75	19.96	114	1.73	52
2000	0.88	0.33 - 1.65	27.38	120	0.89	52
2001	0.55	0.30 - 0.85	20.39	120	0.98	52
2002	0.96	0.42 - 1.70	23.81	120	0.84	52
2003	1.81	0.94 - 3.08	18.02	120	2.38	52
2004	2.62	1.78 - 3.70	10.23	120	4.99	52
2005	5.96	3.48 - 9.81	11.36	120	13.52	52
2006	4.43	2.57 - 7.24	12.36	120	14.70	52
2007	4.79	2.80 - 7.81	11.97	120	7.00	52

Table 18. Channel catfish juvenile indices (1988–2007).

Year	Random Stratified Index (RSI) Geo. Mean	95% C.I.'s	C.V.	N	Original Index River Only	N
1988	0.02	0.00 - 0.06	85.43	52	0.03	52
1989	1.92	1.03 - 3.22	17.10	51	1.27	52
1990	0.04	0.00 - 0.01	72.68	52	0.09	52
1991	0.03	0.00 - 0.08	100.00	72	0.02	52
1992	0.00	0		68	0.00	52
1993	0.04	0.00 - 0.12	77.30	68	0.08	52
1994	0.05	0.00 - 0.11	58.60	68	0.09	52
1995	0.22	0.07 - 0.40	33.76	109	0.40	52
1996	0.13	0.02 - 0.26	43.48	120	0.24	53
1997	0.05	0.00 - 0.12	63.47	120	0.03	52
1998	0.06	0.00 - 0.12	49.85	120	0.04	52
1999	0.00	0		114	0.00	52
2000	0.01	0.00 - 0.02	42.25	120	0.04	52
2001	0.00	0.00 - 0.01	100.00	120	0.00	52
2002	0.00	0.00 - 0.01	100.00	120	0.00	52
2003	0.32	0.16 - 0.50	23.67	120	0.83	52
2004	0.19	0.08 - 0.32	28.85	120	0.39	52
2005	0.02	0.00 - 0.05	56.41	120	0.09	52
2006	0.01	0.00 - 0.02	83.74	120	0.00	52
2007	0.00	0.00 - 0.01	100.00	120	0.00	52

Table 19. Channel catfish Age 1+ indices (1988–2007).

Year	Random Stratified Index (RSI) Geo. Mean	95% C.I.'s	C.V.	N	Original Index River Only (RO)	N
1988	1.41	1.05 - 1.82	9.09	52	0.91	52
1989	1.10	0.52 - 1.91	21.82	51	1.20	52
1990	2.67	1.79 - 3.83	10.56	52	1.52	52
1991	3.37	2.27 - 4.82	9.78	72	1.73	52
1992	1.87	1.30 - 2.58	10.47	68	1.48	52
1993	0.83	0.20 - 1.80	35.01	68	1.15	52
1994	0.81	0.48 - 1.22	17.04	68	1.49	52
1995	0.69	0.39 - 1.05	18.45	109	0.58	52
1996	1.08	0.60 - 1.71	17.84	120	1.17	53
1997	0.84	0.47 - 1.30	18.21	120	1.06	52
1998	0.79	0.46 - 1.19	17.60	120	0.68	52
1999	0.33	0.13 - 0.56	28.23	114	0.77	52
2000	0.25	0.11 - 0.41	26.84	120	0.31	52
2001	0.17	0.04 - 0.33	38.79	120	0.16	52
2002	0.37	0.16 - 0.61	26.31	120	0.36	52
2003	0.28	0.15 - 0.44	22.78	120	0.37	52
2004	0.32	0.14 - 0.53	26.58	120	0.54	52
2005	0.28	0.10 - 0.49	30.49	120	0.31	52
2006	0.21	0.10 - 0.33	25.62	120	0.28	52
2007	0.06	0.02 - 0.11	32.35	120	0.14	52

Table 20. Northern puffer indices (1988–2007).

Year	Random Stratified Index (RSI)				Original Index	
	Geo. Mean	95% C.I.'s	C.V.	N	Bay & River (BRI)	N
1988	0.84	0.58 - 1.15	12.43	147	0.84	147
1989	0.79	0.61 - 0.99	9.00	168	0.79	168
1990	0.68	0.49 - 0.90	11.83	167	0.68	167
1991	0.45	0.32 - 0.59	12.78	155	0.45	155
1992	0.11	0.06 - 0.17	22.68	156	0.11	156
1993	0.17	0.10 - 0.24	18.28	156	0.17	156
1994	0.10	0.05 - 0.16	26.01	156	0.10	156
1995	0.08	0.04 - 0.12	24.11	156	0.08	156
1996	0.14	0.08 - 0.22	22.94	156	0.14	156
1997	0.20	0.12 - 0.28	18.18	156	0.20	156
1998	0.09	0.04 - 0.14	27.44	118	0.09	118
1999	0.25	0.15 - 0.34	17.59	138	0.24	138
2000	0.13	0.08 - 0.19	18.81	156	0.13	156
2001	0.32	0.21 - 0.44	16.06	164	0.32	164
2002	0.16	0.08 - 0.25	24.26	96	0.16	96
2003	0.04	0.01 - 0.08	34.96	156	0.04	156
2004	0.08	0.04 - 0.13	27.68	156	0.08	156
2005	0.04	0.01 - 0.08	37.50	156	0.04	156
2006	0.06	0.03 - 0.11	30.15	156	0.06	156
2007	0.05	0.02 - 0.09	27.96	156	0.05	156

Table 21. Scup indices (1988–2006).

Year	Random Stratified Index (RSI)			
	Geo. Mean	95% C.I.'s	C.V.	N
1988	3.06	2.05 - 4.41	10.20	112
1989	4.92	3.14 - 7.45	10.03	112
1990	1.90	1.11 - 2.99	14.99	103
1991	0.65	0.41 - 0.93	15.67	104
1992	3.36	2.16 - 5.01	10.90	104
1993	0.90	0.53 - 1.35	16.67	104
1994	0.39	0.21 - 0.59	21.36	104
1995	0.54	0.29 - 0.83	20.37	104
1996	0.21	0.09 - 0.35	28.00	104
1997	0.50	0.27 - 0.75	19.83	79
1998	0.27	0.06 - 0.52	37.91	88
1999	0.13	0.02 - 0.25	41.14	105
2000	1.34	0.88 - 1.90	12.80	111
2001	0.24	0.11 - 0.37	24.52	64
2002	0.96	0.58 - 1.42	15.89	104
2003	0.46	0.28 - 0.67	17.38	104
2004	1.11	0.71 - 1.59	13.89	104
2005	1.58	0.99 - 2.36	13.77	104
2006	2.99	2.07 - 4.19	9.47	104

Table 22. Silver perch indices (1988–2007).

Year	Random Stratified Index (RSI)				Original Index			
	Geo. Mean	95% C.I.'s	C.V.	N	Bay & River (BRI)	N	River Only (RO)	N
1988	0.61 (0.39)*	0.35 - 0.92	18.30	172	0.65	172	1.02	65
1989	0.53 (0.28)*	0.33 - 0.76	16.32	189	0.56	189	1.63	63
1990	0.69 (0.4)*	0.49 - 0.92	11.94	185	0.75	185	4.08	59
1991	0.36	0.22 - 0.51	17.33	251	0.40	179	1.47	62
1992	0.80	0.49 - 1.16	15.80	226	0.86	178	1.95	61
1993	0.43	0.28 - 0.61	16.01	224	0.45	180	0.60	63
1994	0.25	0.12 - 0.4	25.42	225	0.26	180	0.37	63
1995	0.62	0.39 - 0.89	15.65	291	0.65	180	1.81	67
1996	0.59	0.38 - 0.84	15.63	304	0.58	183	1.18	66
1997	0.71	0.50 - 0.94	12.07	316	0.79	192	1.43	75
1998	0.24	0.15 - 0.33	16.77	316	0.24	192	0.53	75
1999	0.70	0.49 - 0.94	12.42	309	0.74	186	2.51	75
2000	0.68	0.46 - 0.93	13.56	317	0.76	192	2.12	74
2001	0.70	0.47 - 0.97	13.77	327	0.85	200	3.17	75
2002	0.44	0.24 - 0.67	20.16	269	0.41	146	1.67	75
2003	0.63	0.40 - 0.90	15.49	315	0.66	192	0.71	75
2004	0.34	0.22 - 0.48	16.50	315	0.36	192	0.80	75
2005	0.76	0.52 - 1.03	12.64	315	0.77	192	2.20	75
2006	1.21	0.84 - 1.64	11.31	283	1.22	174	4.45	67
2007	0.75	0.50 - 1.03	13.53	315	0.68	192	2.26	75

* Converted index shown in parentheses

Table 23. Spot indices (1988–2007).

Year	Random Stratified Index (RSI)				Original Index			
	Geo. Mean	95% C.I.'s	C.V.	N	Bay & River (BRI)	N	River Only (RO)	N
1988	67.01 (50.91)*	46.36 - 96.67	4.29	231	67.45	231	50.20	84
1989	31.41 (22.46)*	24.51 - 40.18	3.44	252	32.27	252	54.19	84
1990	44.78 (33.88)*	32.34 - 61.85	4.14	248	45.28	248	53.06	81
1991	16.83	12.78 - 22.08	4.48	334	16.56	238	21.44	83
1992	2.02	1.54 - 2.58	7.78	301	1.96	238	4.39	82
1993	9.99	7.45 - 13.3	5.48	300	9.74	240	11.85	84
1994	9.68	7.28 - 12.79	5.38	300	9.07	240	8.88	84
1995	1.81	1.39 - 2.30	7.87	352	1.52	248	2.37	92
1996	5.26	4.15 - 6.60	5.30	407	4.52	244	4.84	88
1997	11.50	9.11 - 14.45	4.20	421	8.63	256	19.68	100
1998	2.51	1.92 - 3.23	7.36	374	1.88	214	3.04	96
1999	4.72	3.63 - 6.07	6.07	402	3.98	238	6.61	100
2000	3.32	2.57 - 4.23	6.51	421	2.70	253	4.94	97
2001	3.09	2.45 - 3.85	6.06	432	2.83	264	3.69	100
2002	2.89	2.10 - 3.88	8.38	360	2.09	196	3.12	100
2003	2.85	2.25 - 3.56	6.32	420	2.58	256	2.32	100
2004	3.96	3.14 - 4.95	5.68	420	3.21	255	6.91	99
2005	12.12	9.80 - 14.94	3.78	420	8.91	256	16.58	100
2006	3.37	2.71 - 4.16	5.61	420	2.67	256	3.20	100
2007	9.17	7.38 - 11.35	4.18	420	7.79	256	12.75	100

*Converted index shown in parentheses

Table 24. Striped bass indices (1988–2007).

	Random Stratified Index (RSI)				Original Index	
Year	Geo. Mean	95% C.I.'s	C.V.	N	River Only (RO)	N
1988	1.24	0.65 - 2.06	19.19	35	1.93	35
1989	1.65	1.12 - 2.32	11.51	37	1.59	37
1990	1.06	0.49 - 1.84	22.33	36	1.14	36
1991	0.97	0.29 - 2.00	31.00	51	1.02	36
1992	1.28	0.83 - 1.83	13.18	51	2.15	39
1993	2.69	1.23 - 5.10	19.32	53	3.30	41
1994	1.33	0.88 - 1.88	12.58	51	1.07	39
1995	0.61	0.33 - 0.96	20.19	75	1.22	39
1996	0.61	0.32 - 0.95	20.56	90	1.19	40
1997	0.55	0.25 - 0.93	24.75	90	0.41	39
1998	0.89	0.44 - 1.47	21.30	90	1.22	39
1999	0.21	0.00 - 0.47	51.55	84	0.26	39
2000	1.54	0.76 - 2.67	19.70	90	2.72	39
2001	0.53	0.27 - 0.85	21.84	90	1.94	39
2002	0.71	0.42 - 1.07	17.34	90	1.68	39
2003	0.63	0.24 - 1.13	27.59	90	1.01	39
2004	0.33	0.17 - 0.52	22.68	90	0.45	39
2005	0.59	0.30 - 0.95	21.79	90	0.53	39
2006	0.27	0.13 - 0.42	23.65	90	0.55	39
2007	0.37	0.21 - 0.55	20.10	90	0.74	39

Table 25. Summer flounder indices (1988–2007).

Year	Random Stratified Index (RSI)				Original Index			
	Geo. Mean	95% C.I.'s	C.V.	N	Bay & River (BRI)	N	River Only (RO)	N
1988	0.54	0.35 - 0.75	14.99	143	0.53	143	0.54	36
1989	1.24	0.94 - 1.58	8.77	162	1.23	162	0.96	36
1990	2.54	2.06 - 3.09	5.73	162	2.54	162	2.61	36
1991	2.81	2.28 - 3.41	5.51	207	2.78	153	1.42	36
1992	0.92	0. 7- 1.16	9.09	187	0.91	153	0.49	36
1993	0.52	0.37 - 0.67	11.77	185	0.53	153	0.49	36
1994	2.50	1.99 - 3.10	6.30	186	2.50	153	1.08	36
1995	0.71	0.54 - 0.91	10.21	218	0.72	149	0.74	36
1996	0.81	0.62 - 1.02	9.32	224	0.86	153	0.62	36
1997	0.89	0.69 - 1.12	8.77	226	0.97	153	0.70	36
1998	0.73	0.55 - 0.93	9.92	226	0.78	153	0.17	36
1999	0.53	0.41 - 0.67	9.94	219	0.58	147	0.36	36
2000	0.57	0.43 - 0.73	10.81	227	0.62	154	0.52	36
2001	0.47	0.34 - 0.61	11.84	236	0.52	161	0.53	36
2002	0.77	0.54 - 1.04	12.21	179	0.80	107	0.43	36
2003	0.44	0.33 - 0.56	10.95	225	0.43	153	0.50	36
2004	1.30	1.03 - 1.60	7.50	225	1.40	153	1.17	36
2005	0.35	0.25 - 0.46	13.18	225	0.36	153	0.29	36
2006	0.80	0.60 - 1.02	10.03	203	0.87	139	0.59	32
2007	1.00	0.78 - 1.24	8.22	225	1.04	153	0.53	36

Table 26. Weakfish indices (1988–2007).

Year	Random Stratified Index (RSI)				Original Index			
	Geo. Mean	95% C.I.'s	C.V.	N	Bay & River (BRI)	N	River Only (RO)	N
1988	8.13 (8.05)*	5.37 - 12.07	8.12	173	8.89	173	21.72	63
1989	11.74 (11.91)*	8.18 - 16.88	6.44	189	12.22	189	21.27	63
1990	4.46 (4.29)*	3.1 - 6.26	8.44	184	4.87	184	30.01	59
1991	3.21	2.38 - 4.25	7.64	252	3.56	179	15.32	62
1992	6.78	4.79 - 9.47	7.21	226	6.93	178	15.91	61
1993	5.84	4.12 - 8.15	7.55	225	6.12	180	15.42	63
1994	2.60	1.84 - 3.55	9.21	225	2.67	180	7.04	63
1995	6.62	4.89 - 8.86	6.34	275	6.07	186	11.00	69
1996	7.26	5.33 - 9.78	6.31	305	7.85	183	7.42	66
1997	6.81	5.26 - 8.74	5.38	316	7.15	192	14.82	75
1998	7.60	5.46 - 10.45	6.65	269	8.18	150	9.95	71
1999	6.78	5.01 - 9.06	6.28	303	7.38	180	16.25	75
2000	8.35	6.34 - 10.92	5.42	316	9.39	191	11.09	74
2001	5.09	3.74 - 6.82	6.93	327	5.14	200	11.52	75
2002	6.93	4.27 - 10.94	9.89	270	6.30	147	8.59	75
2003	9.23	6.72 - 12.54	6.04	315	9.34	192	5.42	75
2004	6.66	4.94 - 8.88	6.24	315	7.27	192	10.47	75
2005	5.69	4.26 - 7.50	6.31	315	5.93	192	7.10	75
2006	6.34	4.83 - 8.25	5.80	315	6.21	192	6.20	75
2007	5.35	3.99 - 7.08	6.51	315	5.30	192	14.37	75

* Converted index shown in parentheses

Table 27. White catfish juvenile indices (1988–2007).

Year	Random Stratified Index (RSI) Geo. Mean	95% C.I.'s	C.V.	N	Original Index River Only (RO)	N
1988	0.25	0.11 - 0.41	26.68	52	0.61	52
1989	3.63	2.01 - 6.12	14.03	51	3.33	52
1990	0.76	0.57 - 0.97	9.89	52	0.82	52
1991	0.06	0.02 - 0.11	34.21	72	0.19	52
1992	0.74	0.57 - 0.92	9.04	68	0.50	52
1993	0.80	0.45 - 1.23	18.34	68	1.14	52
1994	0.12	0.06 - 0.19	25.82	68	0.34	52
1995	0.21	0.08 - 0.35	29.33	109	0.46	52
1996	0.36	0.18 - 0.55	22.23	120	1.18	53
1997	0.37	0.23 - 0.53	17.47	120	0.94	52
1998	0.07	0.04 - 0.10	22.96	120	0.34	52
1999	0.003	0.00 - 0.01	100.00	114	0.00	52
2000	0.05	0.00 - 0.12	58.53	120	0.09	52
2001	0.02	0.00 - 0.04	73.60	120	0.03	52
2002	0.00	0	.	120	0.00	52
2003	0.29	0.17 - 0.42	19.28	120	0.99	52
2004	0.12	0.04 - 0.20	33.23	120	0.19	52
2005	0.04	0.00 - 0.09	44.35	120	0.18	52
2006	0.08	0.03 - 0.14	32.32	120	0.18	52
2007	0.02	0.00 - 0.04	46.28	120	0.07	52

Table 28. White catfish age 1+ indices (1988–2007).

Year	Random Stratified Index (RSI) Geo. Mean	95% C.I.'s	C.V.	N	Original Index River Only (RO)	N
1988	1.88	1.29 - 2.62	10.81	52	3.16	52
1989	3.23	1.68 - 5.67	15.78	51	4.35	52
1990	3.46	2.13 - 5.34	11.82	52	6.75	52
1991	2.04	0.90 - 3.87	21.14	72	2.31	52
1992	3.77	3.03 - 4.63	5.34	68	3.97	52
1993	2.25	1.19 - 3.82	16.69	68	1.66	52
1994	1.59	1.09 - 2.22	11.37	68	2.72	52
1995	0.94	0.45 - 1.61	22.21	109	1.77	52
1996	1.05	0.76 - 1.40	10.78	120	3.11	53
1997	1.85	1.32 - 2.49	9.82	120	3.45	52
1998	1.21	0.76 - 1.77	14.40	120	2.45	52
1999	0.56	0.36 - 0.79	15.31	114	1.51	52
2000	0.29	0.15 - 0.45	22.91	120	0.66	52
2001	0.29	0.14 - 0.47	24.65	120	0.54	52
2002	0.36	0.11 - 0.66	33.57	120	0.52	52
2003	0.48	0.26 - 0.74	20.34	120	1.13	52
2004	0.28	0.15 - 0.42	21.66	120	0.66	52
2005	0.41	0.23 - 0.62	19.83	120	0.98	52
2006	0.34	0.22 - 0.11	16.10	120	0.73	52
2007	0.23	0.11 - 0.35	24.29	120	0.62	52

Table 29. White perch juvenile indices (1988–2007).

Year	Random Stratified Index (RSI) Geo. Mean	95% C.I.'s	C.V.	N	Original Index River Only (RO)	N
1988	6.15	3.68 - 9.91	10.75	35	5.29	35
1989	12.93	6.69 - 24.25	11.29	37	13.33	37
1990	3.24	1.84 - 5.32	13.89	36	3.31	36
1991	3.40	1.17 - 7.94	23.89	51	2.30	36
1992	1.54	0.83 - 2.52	17.56	51	1.21	39
1993	17.87	5.30 - 55.51	18.67	53	17.91	41
1994	12.33	6.84 - 21.68	10.26	51	8.43	39
1995	1.92	0.98 - 3.29	18.01	75	4.61	39
1996	24.41	12.94 - 45.29	9.27	90	21.61	40
1997	9.34	6.04 - 14.19	8.22	90	10.00	39
1998	3.84	1.98 - 6.86	15.38	90	7.13	39
1999	0.74	0.39 - 1.19	20.54	84	2.38	39
2000	8.23	4.01 - 15.99	13.74	90	16.90	39
2001	1.93	0.95 - 3.39	18.83	90	5.99	39
2002	4.66	3.47 - 6.16	6.77	90	9.48	39
2003	21.98	9.91 - 47.40	11.89	90	15.70	39
2004	6.52	3.27 - 12.26	14.05	90	4.32	39
2005	11.75	6.70 - 20.11	9.91	90	8.39	39
2006	4.35	2.52 - 7.14	12.48	90	5.00	39
2007	3.10	1.43 - 5.93	18.56	90	4.62	39

Table 30. White perch age 1+ indices (1988–2007).

Year	Random stratified Index (RSI) Geo. Mean	95% C.I.'s	C.V.	N	Original Index River Only (RO)	N
1988	39.57	26.69 - 58.42	5.15	46	35.10	46
1989	22.78	16.00 - 32.25	5.29	46	25.86	46
1990	35.39	21.9 - 56.83	6.44	45	31.97	45
1991	32.45	23.82 - 44.09	4.25	65	29.49	44
1992	11.17	7.47 - 16.47	7.24	64	15.77	48
1993	10.11	4.69 - 20.69	13.90	66	15.04	50
1994	21.29	13.52 - 33.2	6.90	64	18.77	48
1995	10.76	6.53 - 17.36	9.04	98	40.82	48
1996	9.03	5.29 - 15.00	10.13	116	12.78	50
1997	19.37	10.56 - 34.90	9.40	120	20.25	52
1998	10.89	6.70 - 17.36	8.78	120	27.44	52
1999	10.34	5.97 - 17.46	10.03	114	22.25	52
2000	7.65	3.79 - 14.63	13.72	120	17.31	52
2001	4.62	2.54 - 7.92	13.36	120	17.09	52
2002	7.22	4.99 - 10.28	7.51	120	20.61	52
2003	19.13	9.95 - 36.00	10.14	120	27.35	52
2004	6.84	3.83 - 11.72	11.76	120	8.71	52
2005	8.40	5.30 - 13.04	8.95	120	9.34	52
2006	6.45	4.09 - 9.89	9.48	120	13.11	52
2007	6.48	3.88 - 10.46	10.61	120	19.58	52

FIGURES

Figure 1. The VIMS Trawl Survey random stratified design of the Chesapeake Bay. Transect lines indicate geographic regions as designated below. (* indicates areas not presently sampled).

Chesapeake Bay	B1	Bottom Bay
	B2	Lower Bay
	B3	Upper Bay
	B4	Top Bay
James River	J1	Bottom James
	J2	Lower James
	J3	Upper James
	J4	Top James
	J5*	Freshwater James 1
	J6*	Freshwater James 2
	JE*	Elizabeth River (sampled for EFH 11/99-5/00)
	JC*	Chickahominy River
York River	Y1	Bottom York
	Y2	Lower York
	Y3	Upper York
	Y4	Top York (lower Pamunkey River)
	PM*	Pamunkey River
	MP1*	Lower Mattaponi
	MP2*	Upper Mattaponi
Rappahannock River	R1	Bottom Rappahannock
	R2	Lower Rappahannock
	R3	Upper Rappahannock
	R4	Top Rappahannock
	R5*	Freshwater Rappahannock
	RC*	Corrotoman River
Potomac River	P1*	Potomac (River Mile 0-10)
	P2*	Potomac (River Mile 10-20)
	P3*	Potomac (River Mile 20-30)
Mobjack Bay	MB*	(re-established July 1998; discontinued 2001)
Atlantic Ocean	AT*	
Piankatank River	PK*	(re-established as of July 1998; discontinued 2001)
Pocomoke Sound	CP*	(re-established as of July 1998; discontinued 2001)
Great Wicomico River	GW*	(as of July 1998; discontinued 2001)

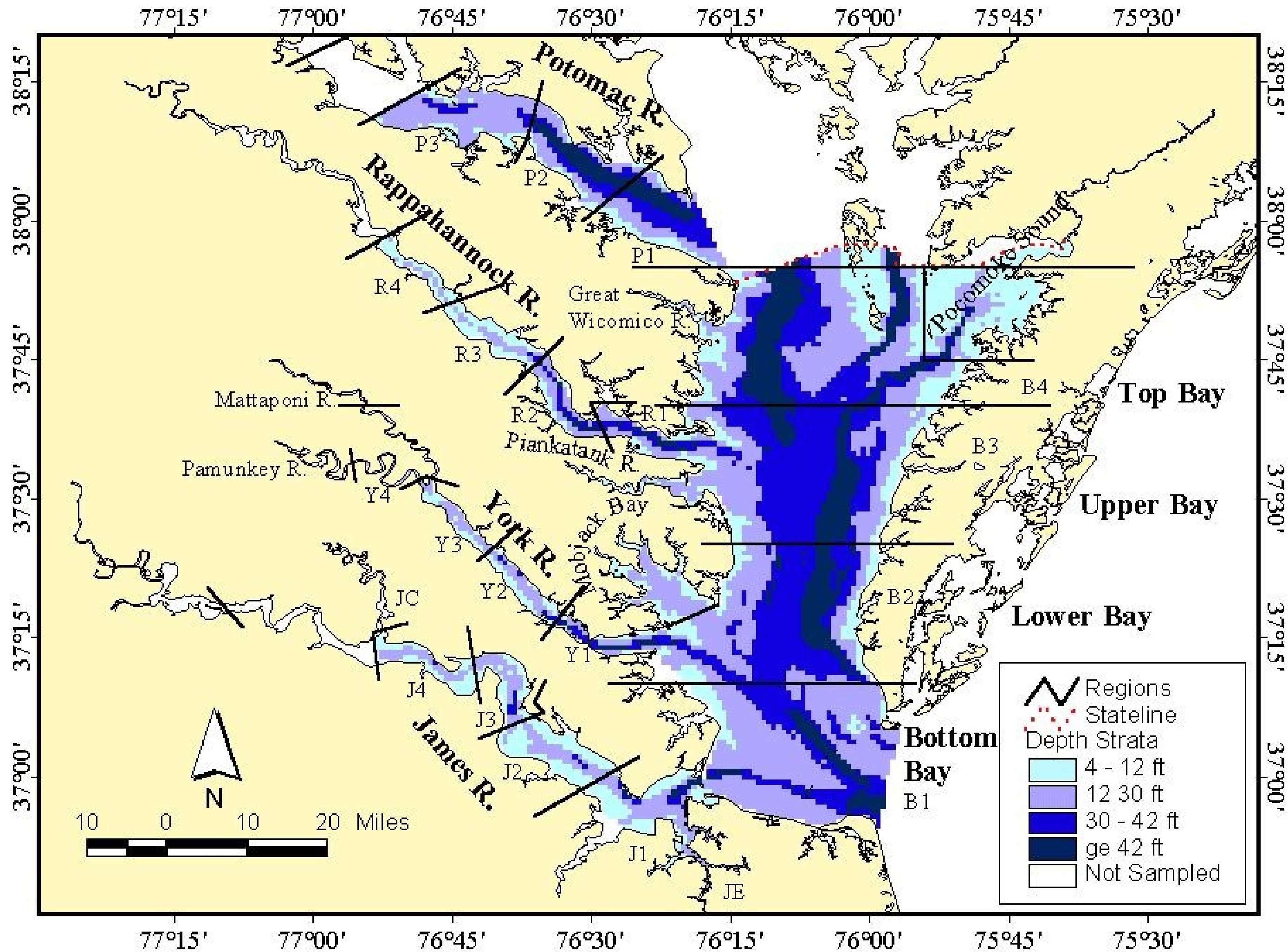


Figure 1 (cont.)

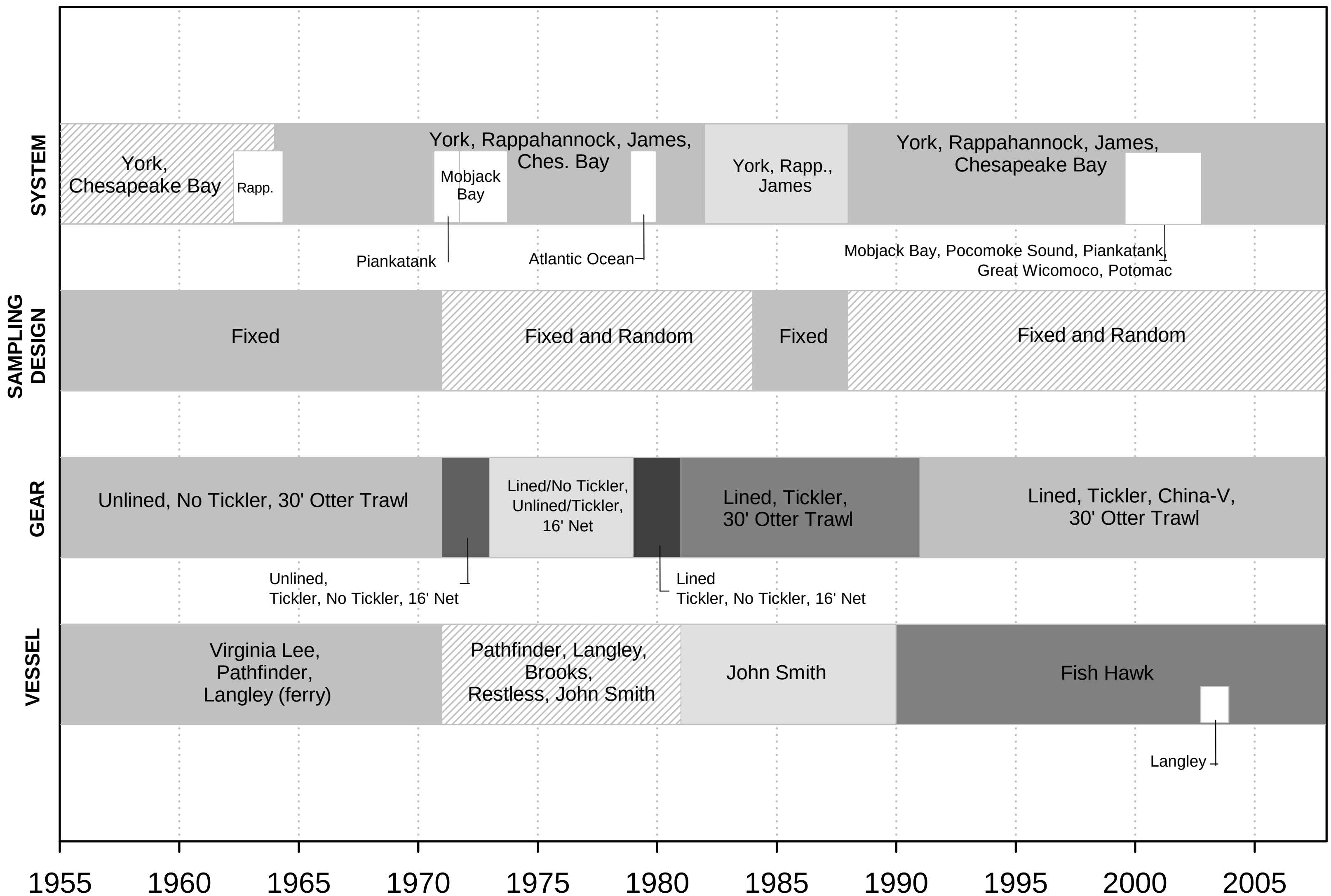


Figure 2. Sampling changes VIMS Juvenile Fish Trawl Survey, 1955 – May 2008.

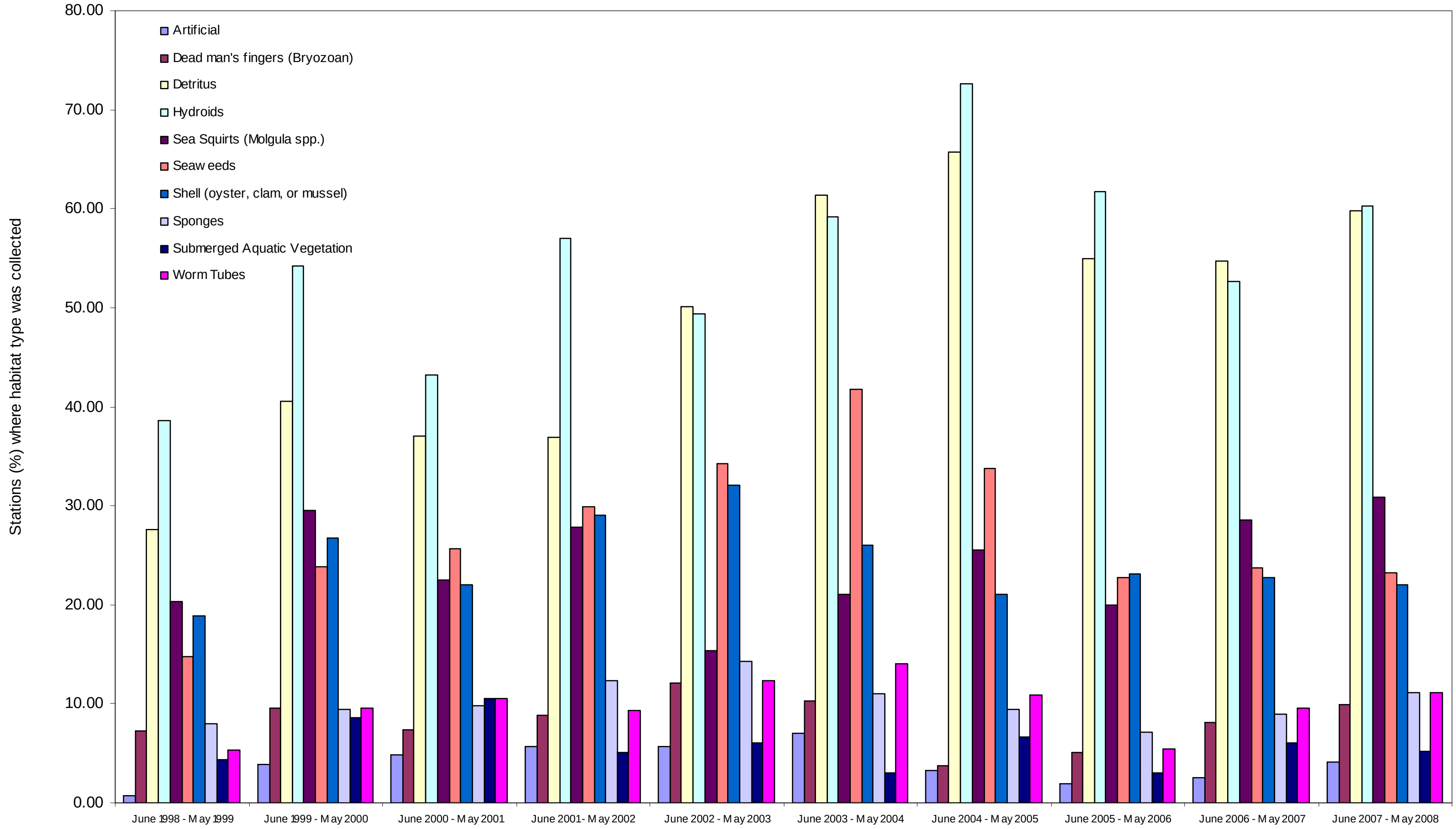
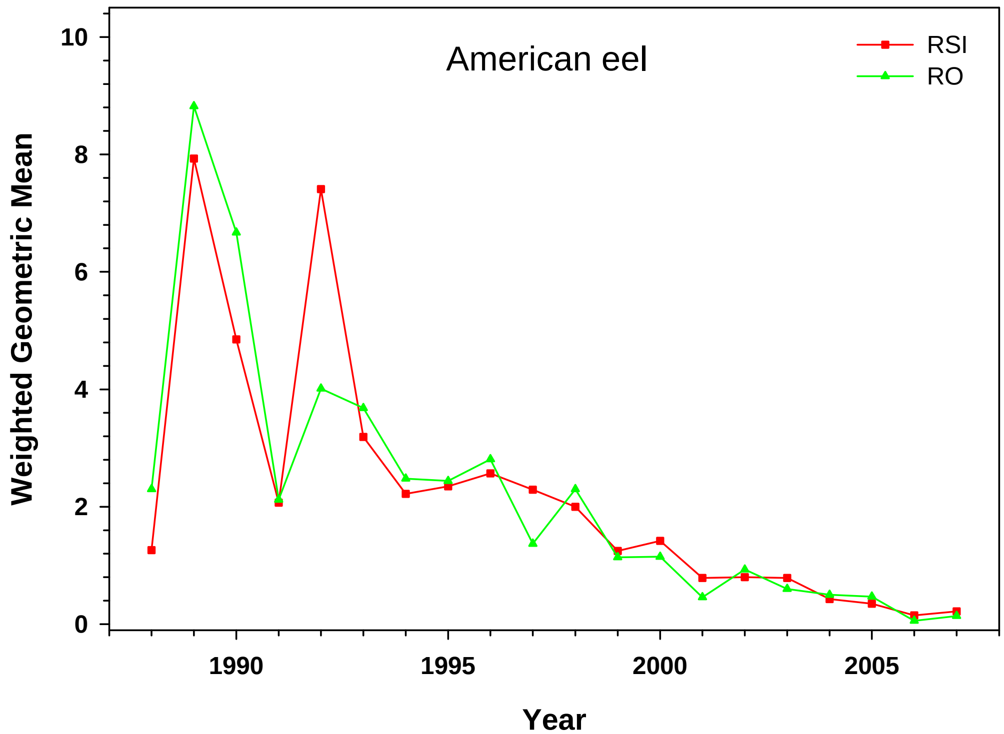


Figure 3. Annual comparisons of substrate type collected in trawl samples from June 1998 to May 2008. Shown are percent of samples that contained a particular habitat category.



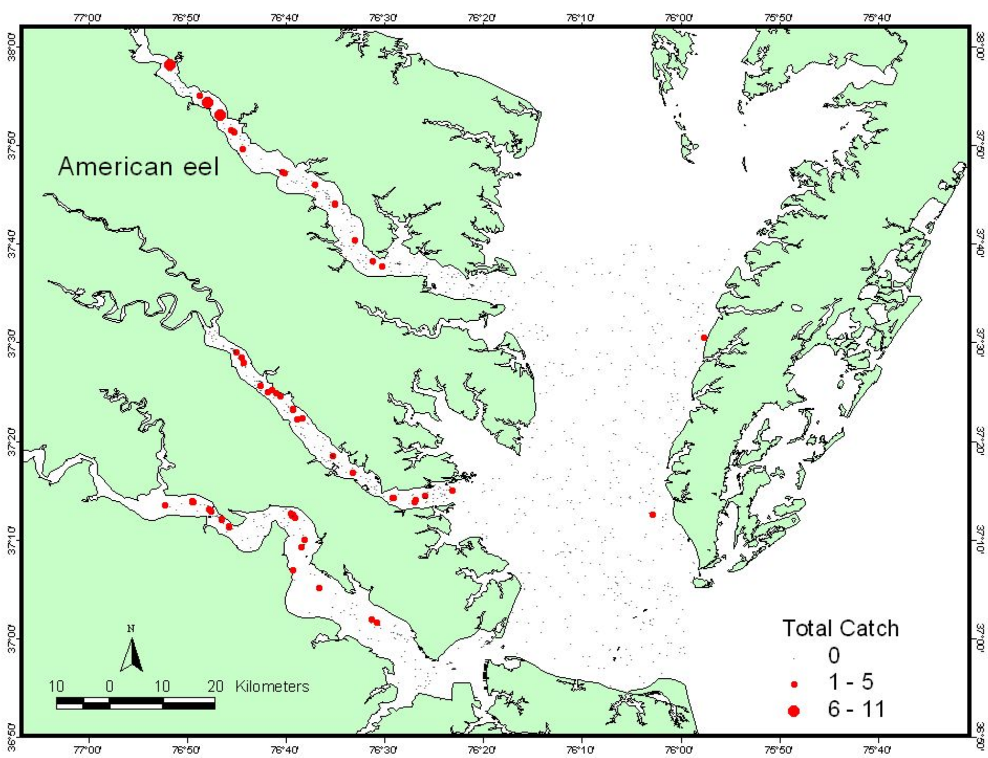
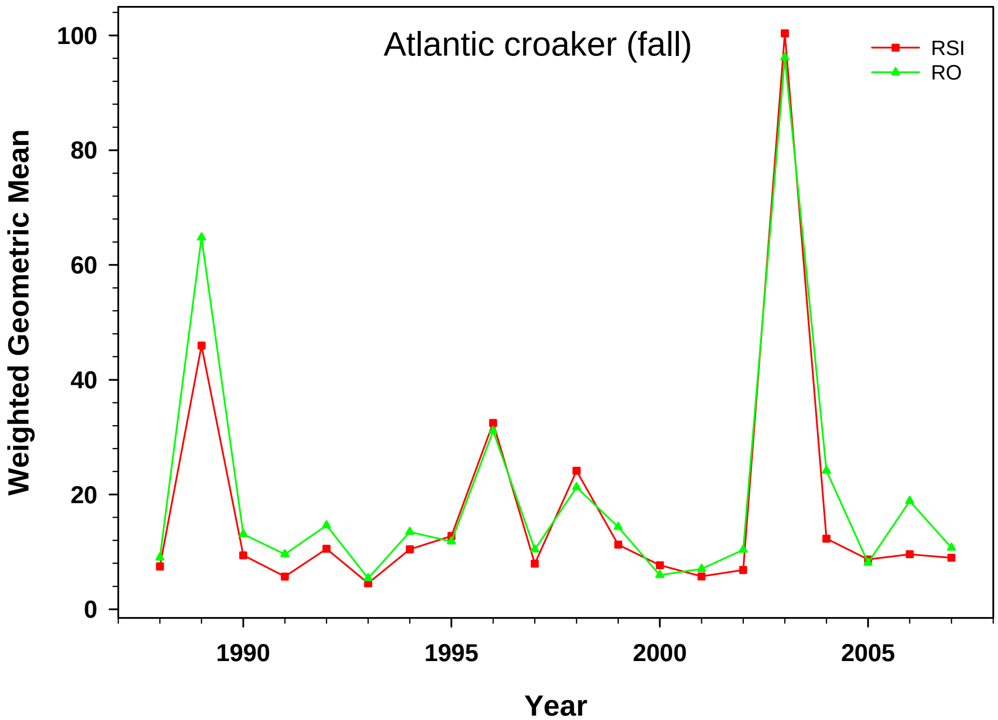


Figure 4. American eel random stratified (RSI) and fixed transect (Rivers only - RO) indices (Top), and distribution of American eel (all year classes combined) from June 2007 through May 2008 (Bottom).



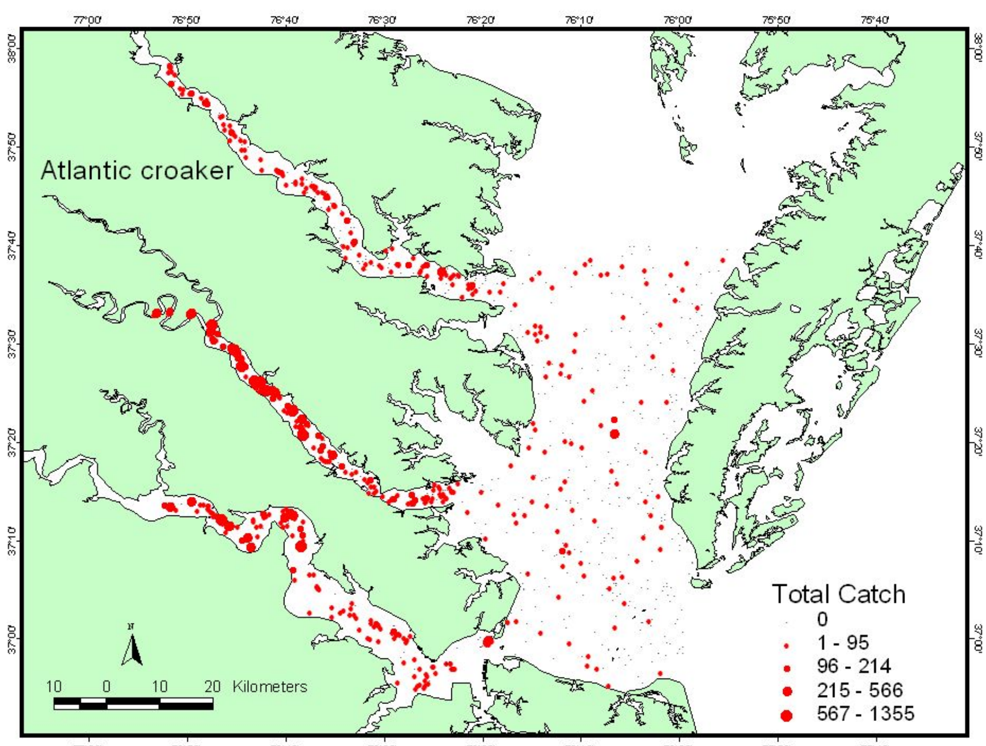


Figure 5. Fall juvenile Atlantic croaker random stratified (RSI) and fixed transect (Rivers only - RO) indices (Top), and distribution of index-sized Atlantic croaker (fall and spring) from June 2007 through May 2008 (Bottom).

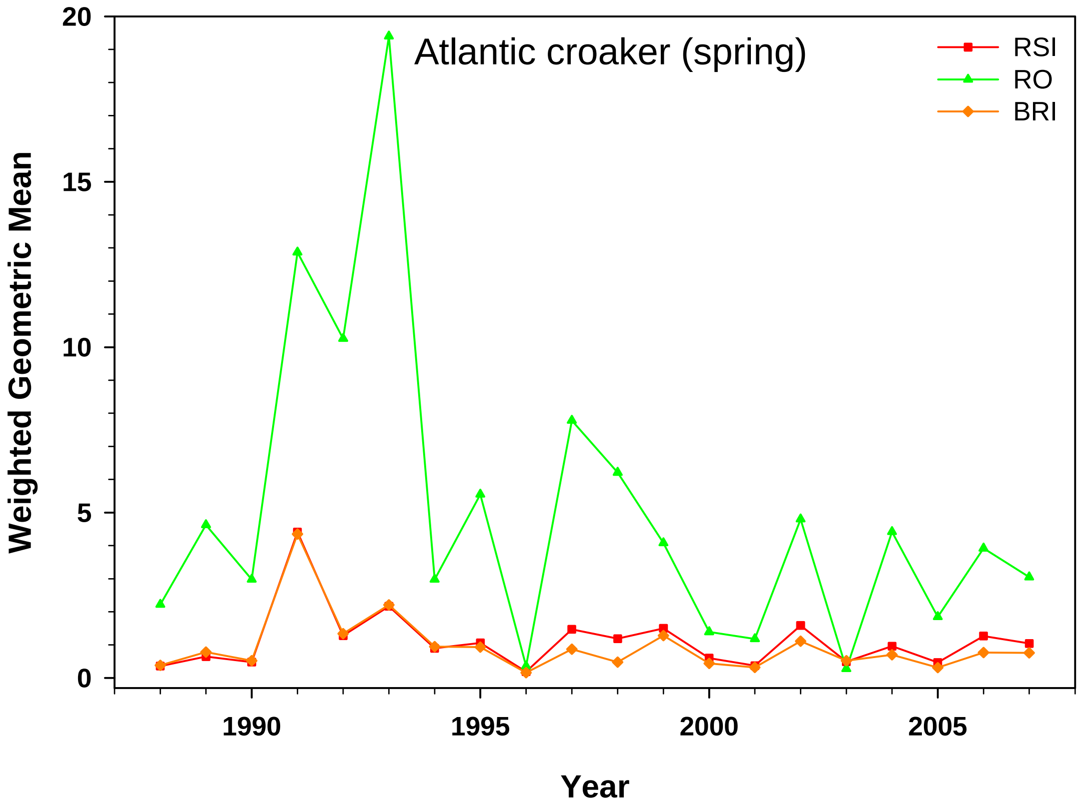
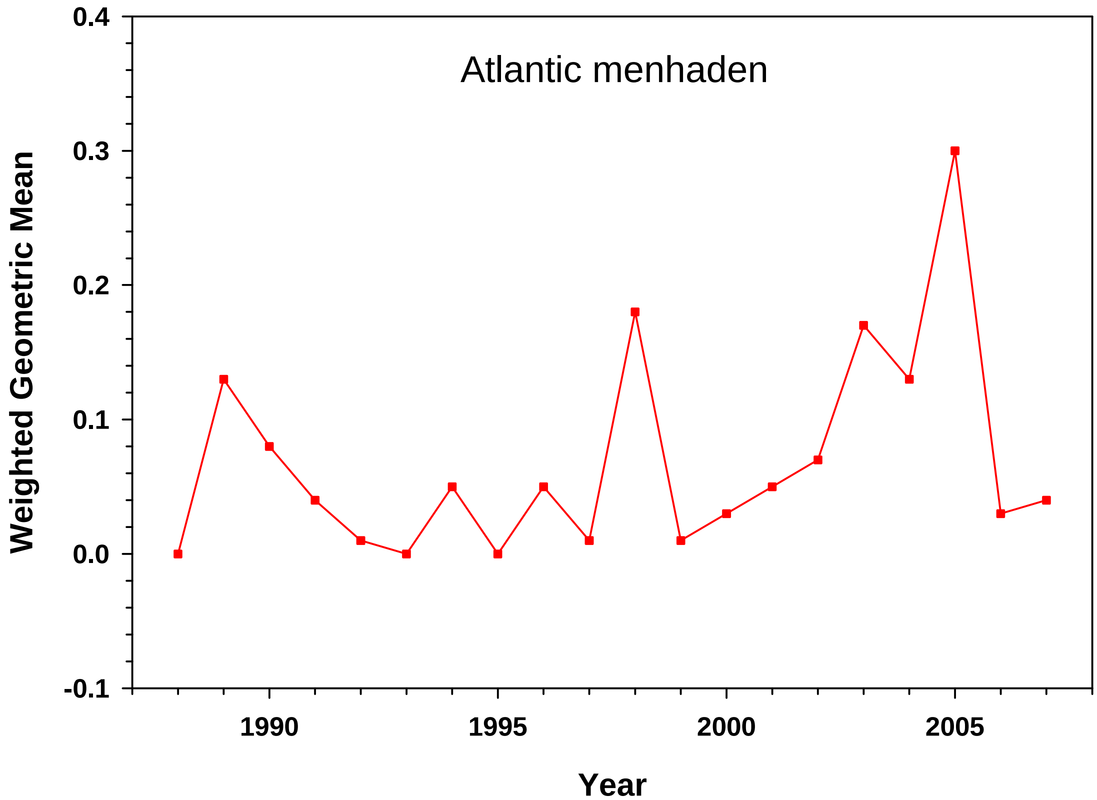


Figure 6. Spring juvenile Atlantic croaker random stratified (RSI), fixed transect (Rivers only - RO), and Bay and fixed river station (BRI) indices.



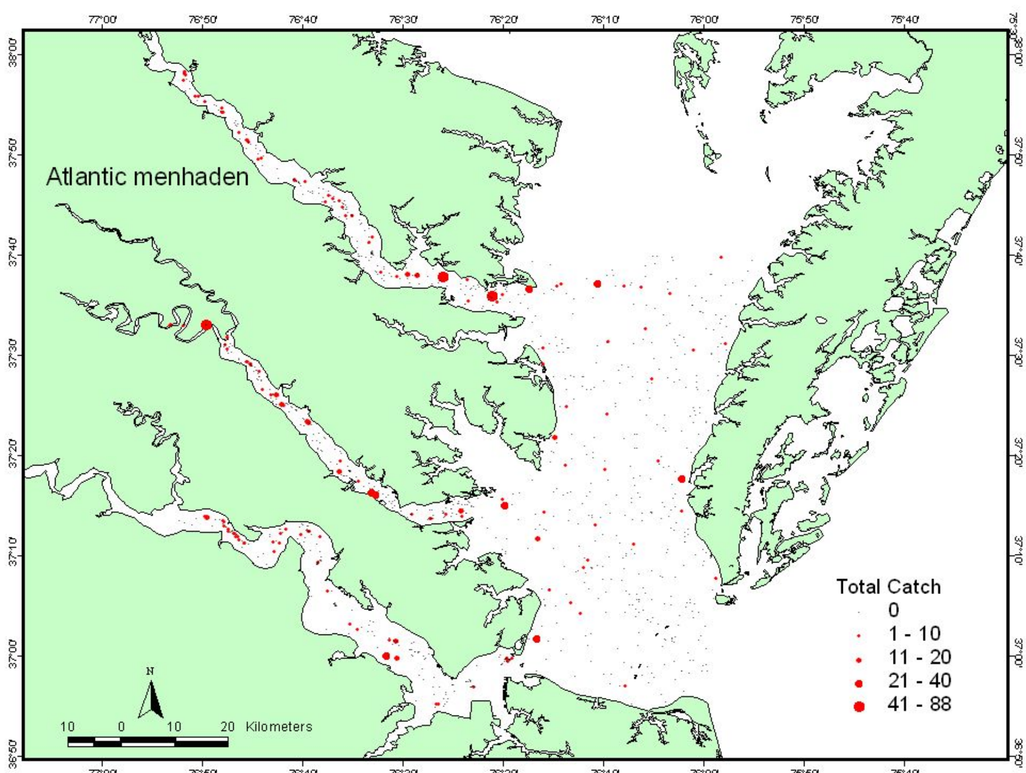
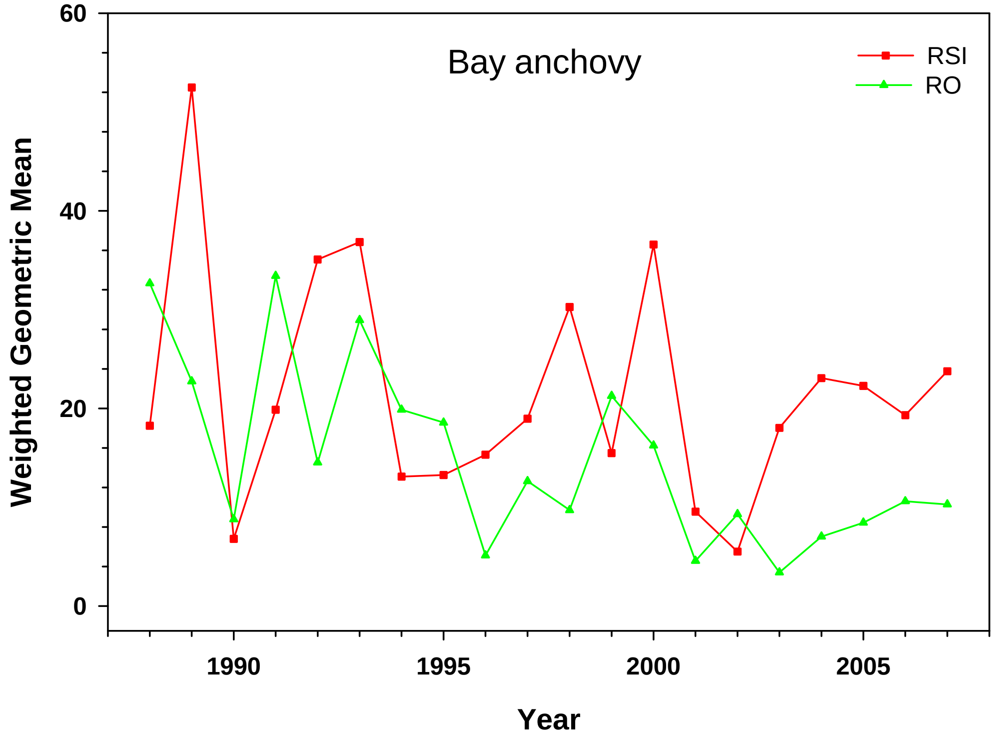


Figure 7. Juvenile Atlantic menhaden random stratified index (RSI; Top), and distribution of index-sized Atlantic menhaden from June 2007 through May 2008 (Bottom).



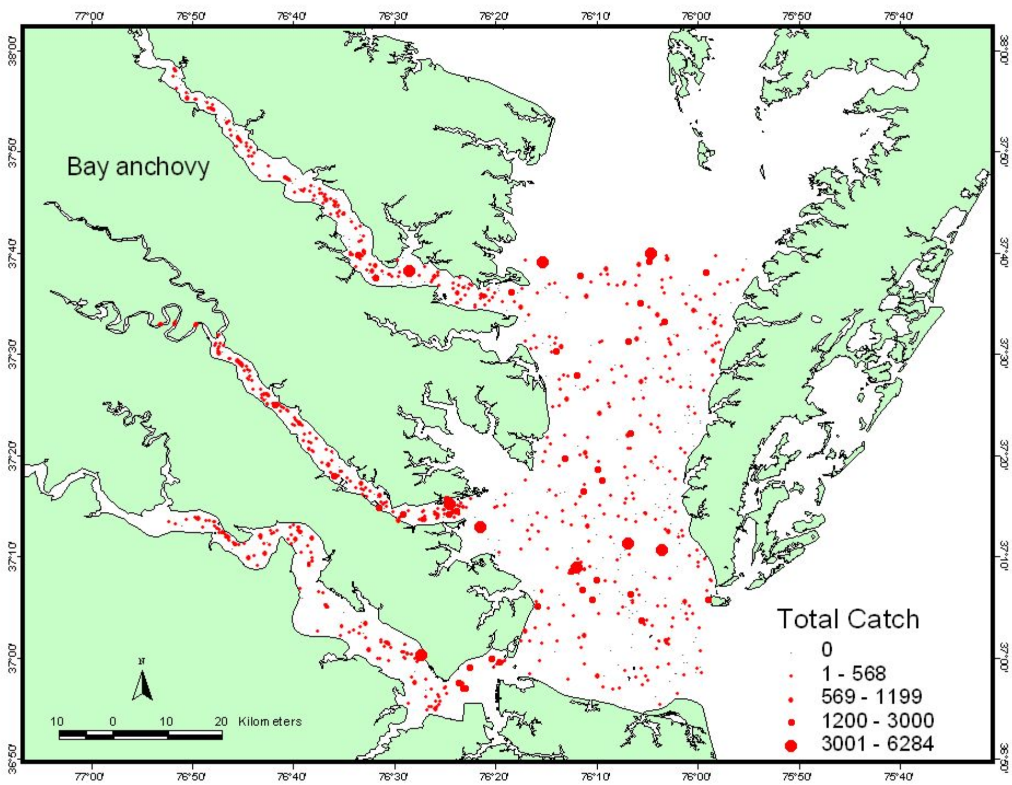
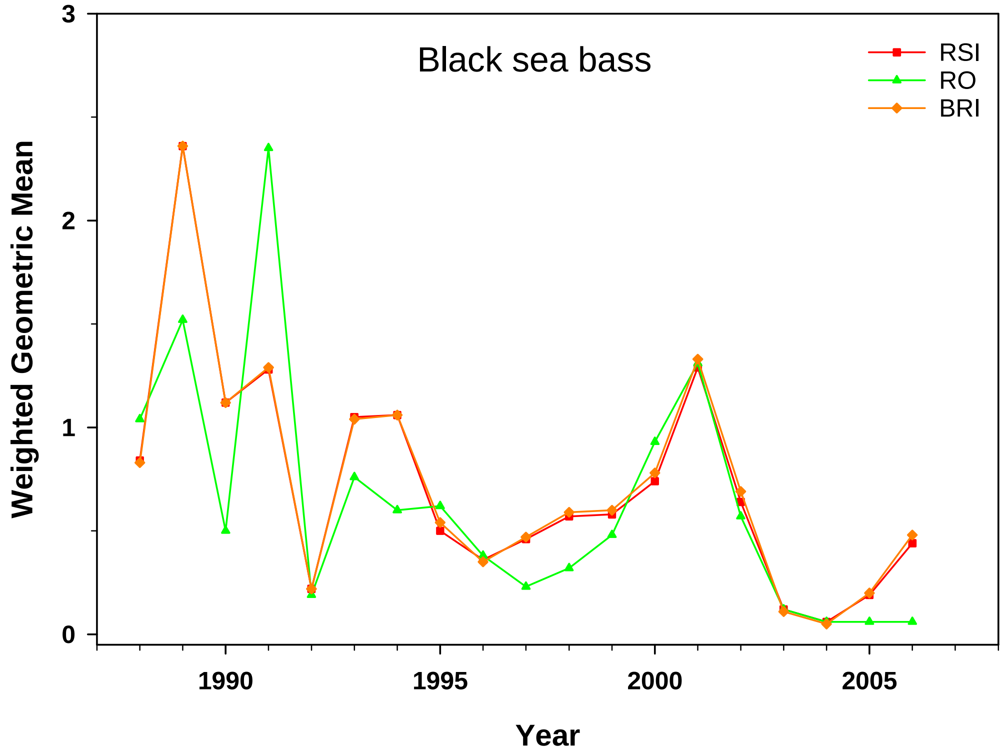


Figure 8. Bay anchovy random stratified index (RSI) and fixed transect (Rivers only - RO) indices (Top), and distribution of index-sized bay anchovy from June 2007 through May 2008 (Bottom).



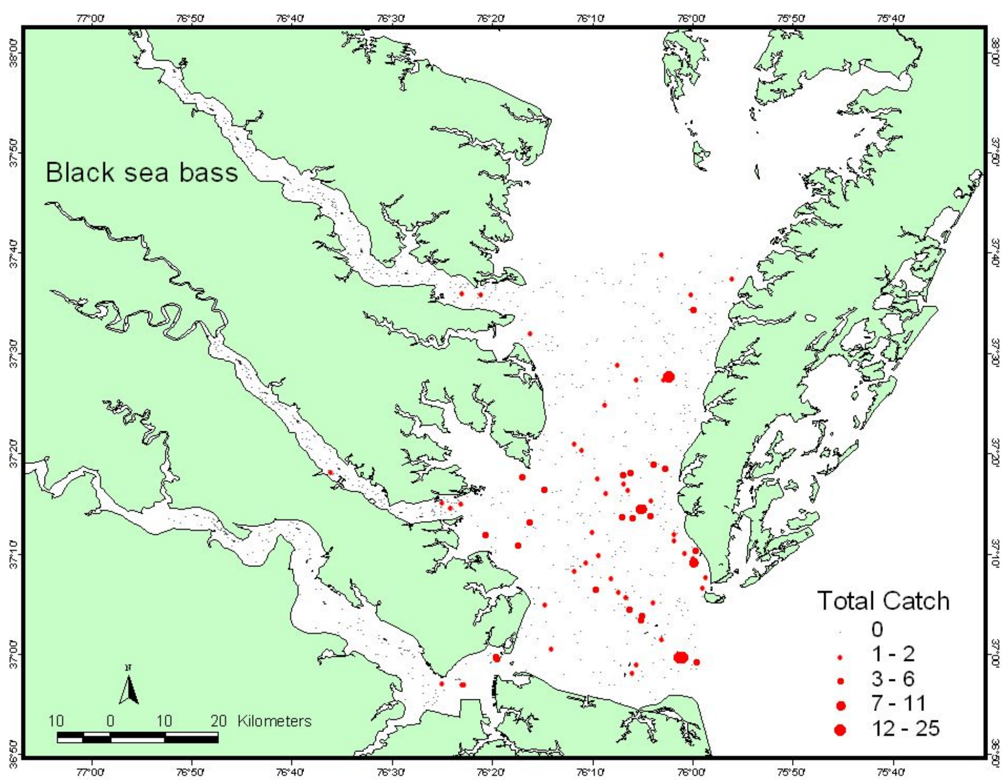
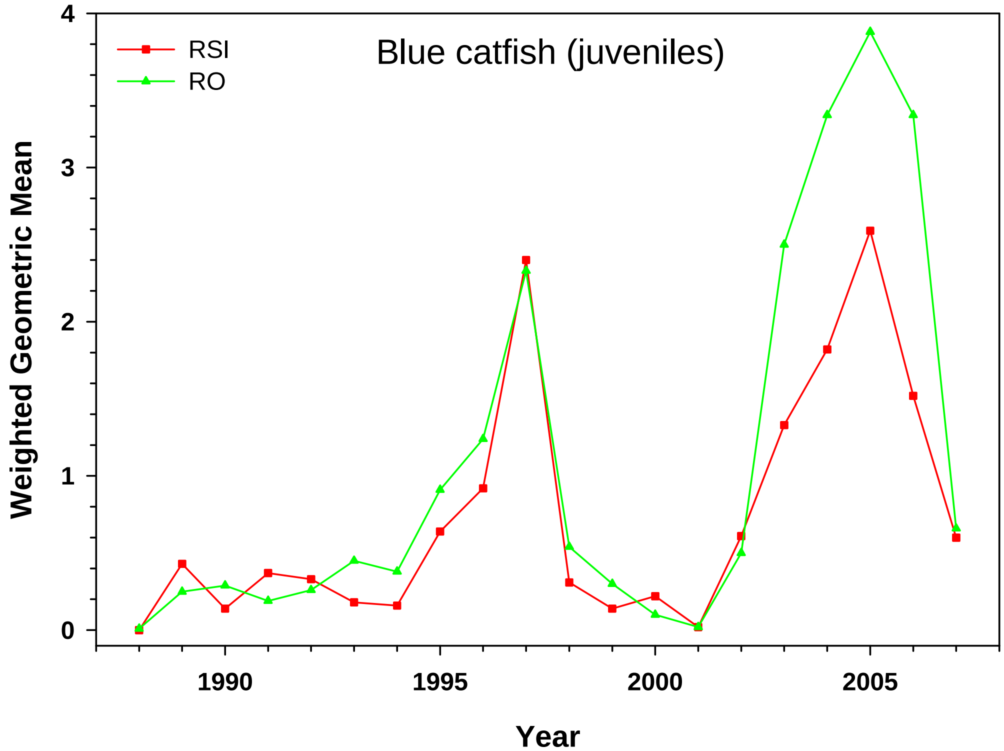


Figure 9. Black sea bass random stratified index (RSI) and fixed transect (Rivers only - RO), and bay and fixed river station (BRI) indices (Top), and distribution of index-sized juvenile black sea bass from June 2007 through May 2008 (Bottom).



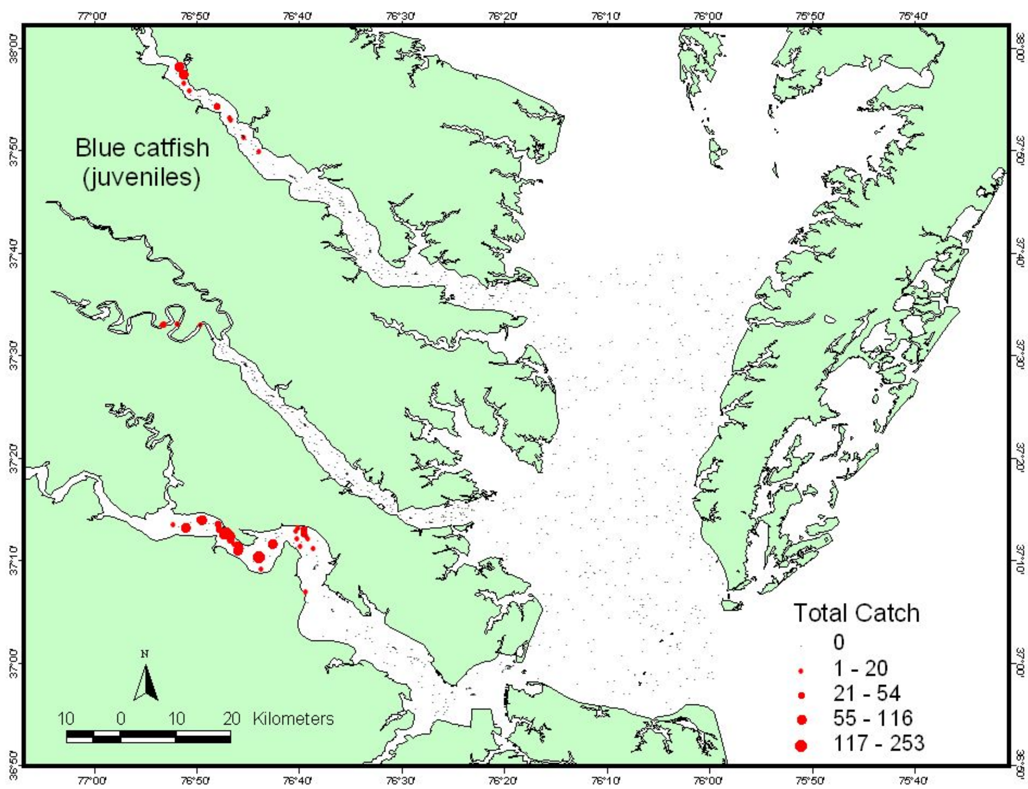
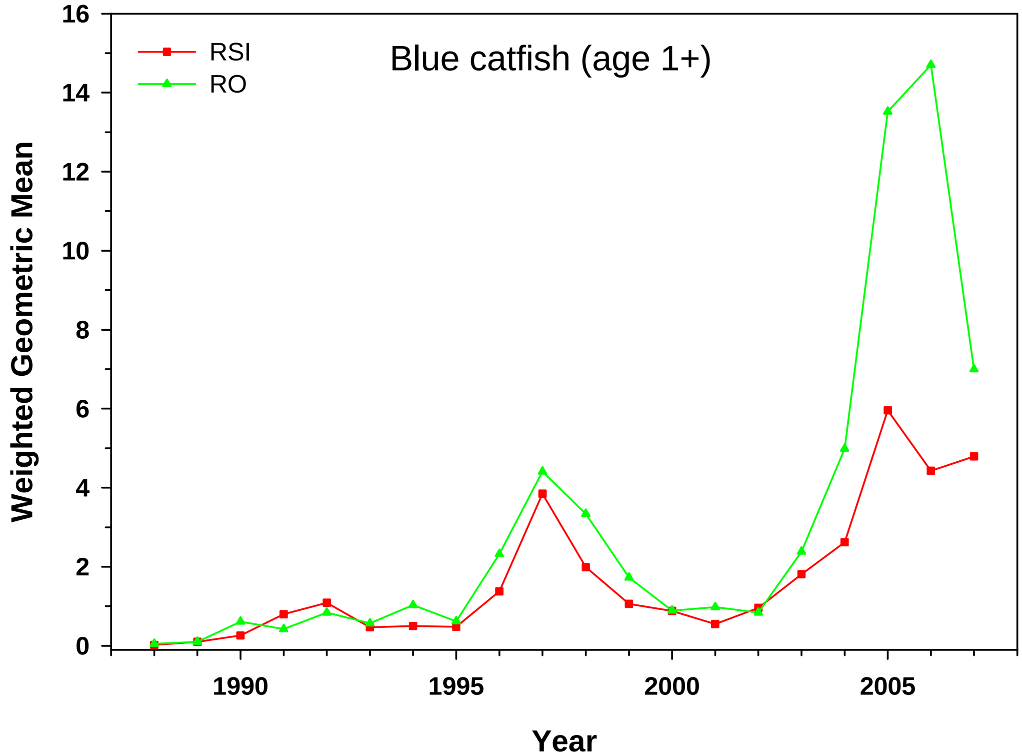


Figure 10. Juvenile blue catfish random stratified index (RSI) and fixed transect (Rivers only - RO) indices (Top), and distribution of index-sized juvenile blue catfish from June 2007 through May 2008 (Bottom).



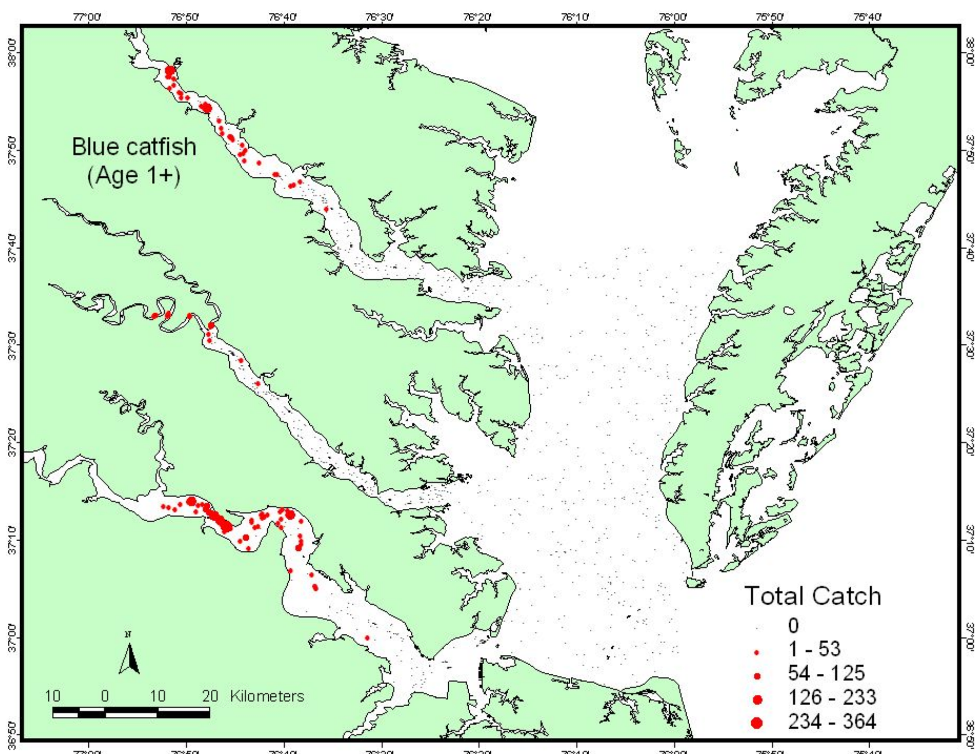
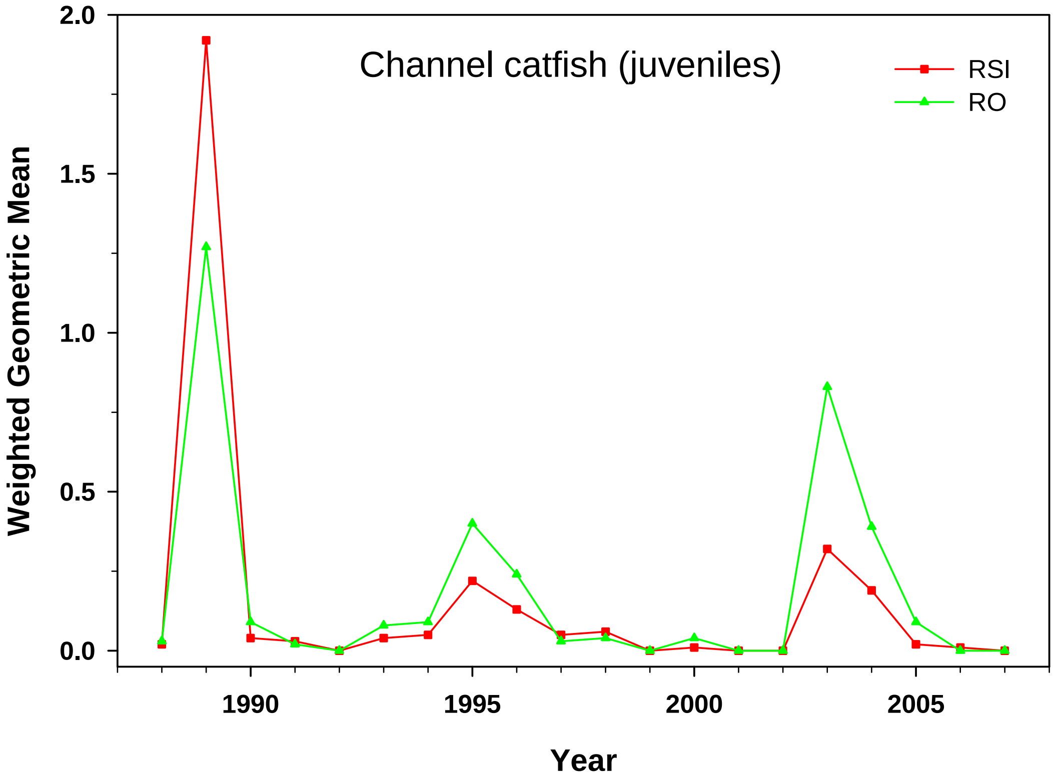


Figure 11. Age1+ blue catfish random stratified index (RSI) and fixed transect (Rivers only - RO) indices (Top), and distribution of age 1+ blue catfish from June 2007 through May 2008 (Bottom).



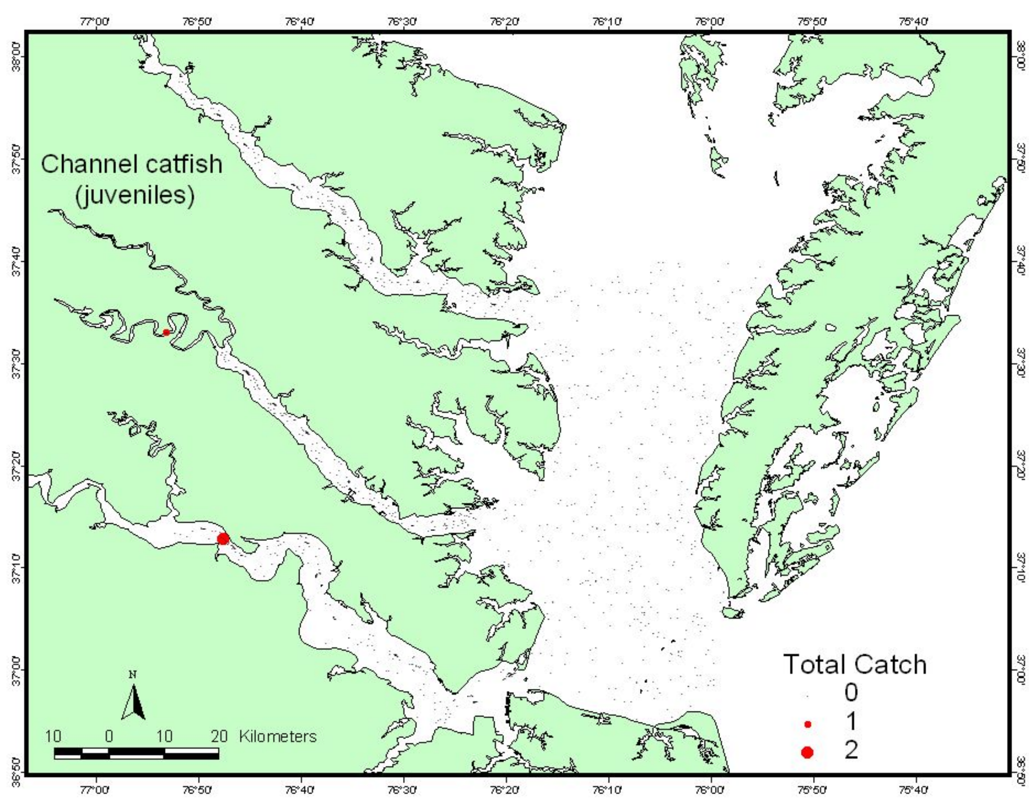


Figure 12. Juvenile channel catfish random stratified index (RSI) and fixed transect (Rivers only - RO) indices (Top), and distribution of index-sized juvenile channel catfish from June 2007 through May 2008 (Bottom).

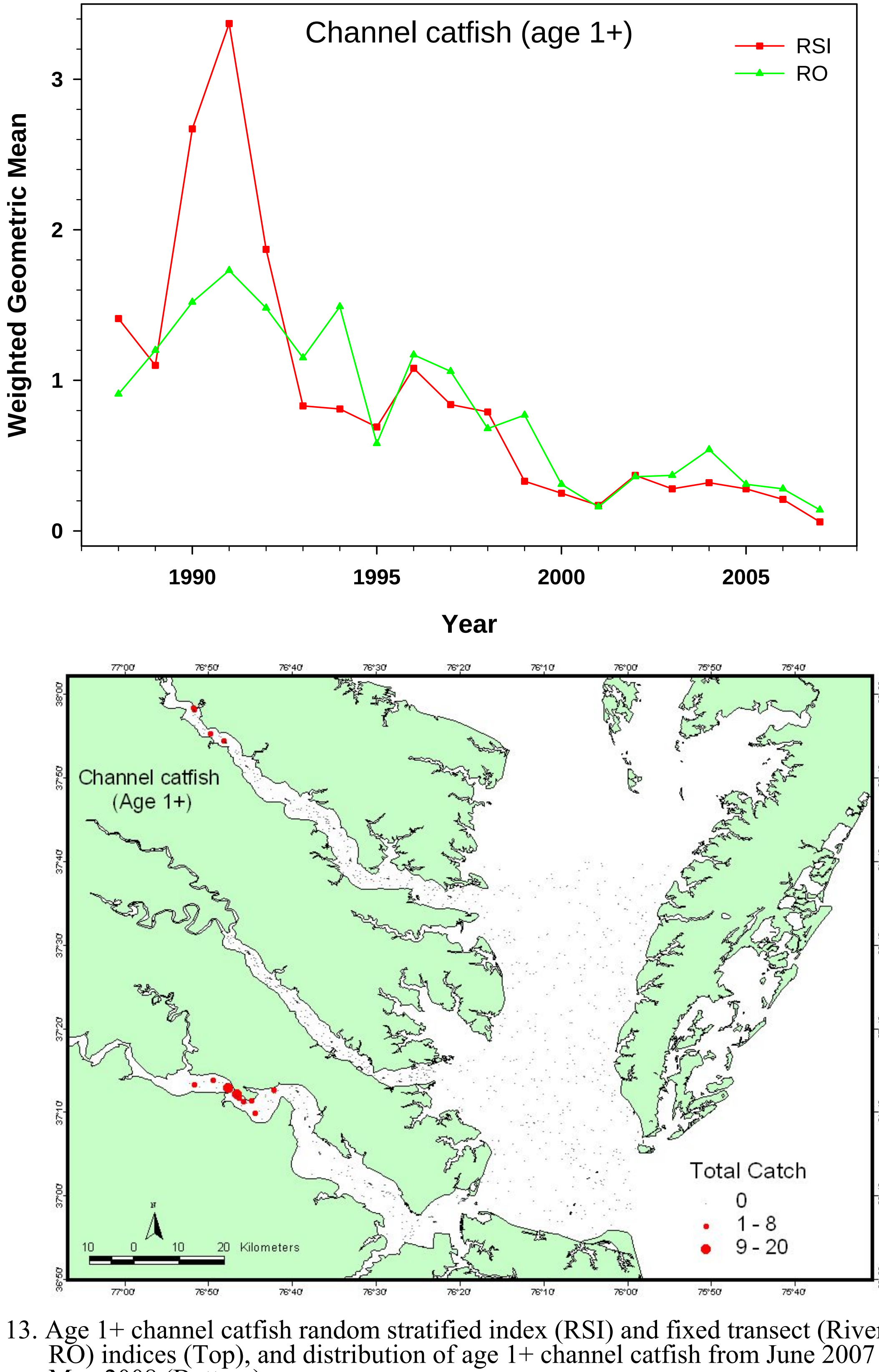
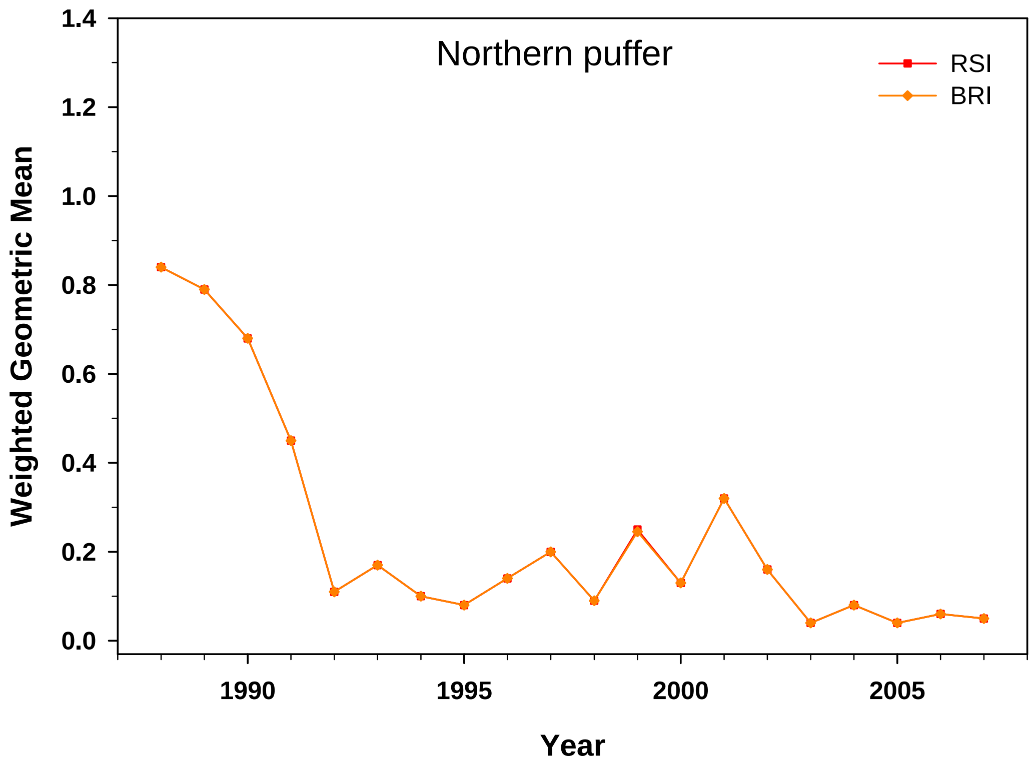


Figure 13. Age 1+ channel catfish random stratified index (RSI) and fixed transect (Rivers only - RO) indices (Top), and distribution of age 1+ channel catfish from June 2007 through May 2008 (Bottom).



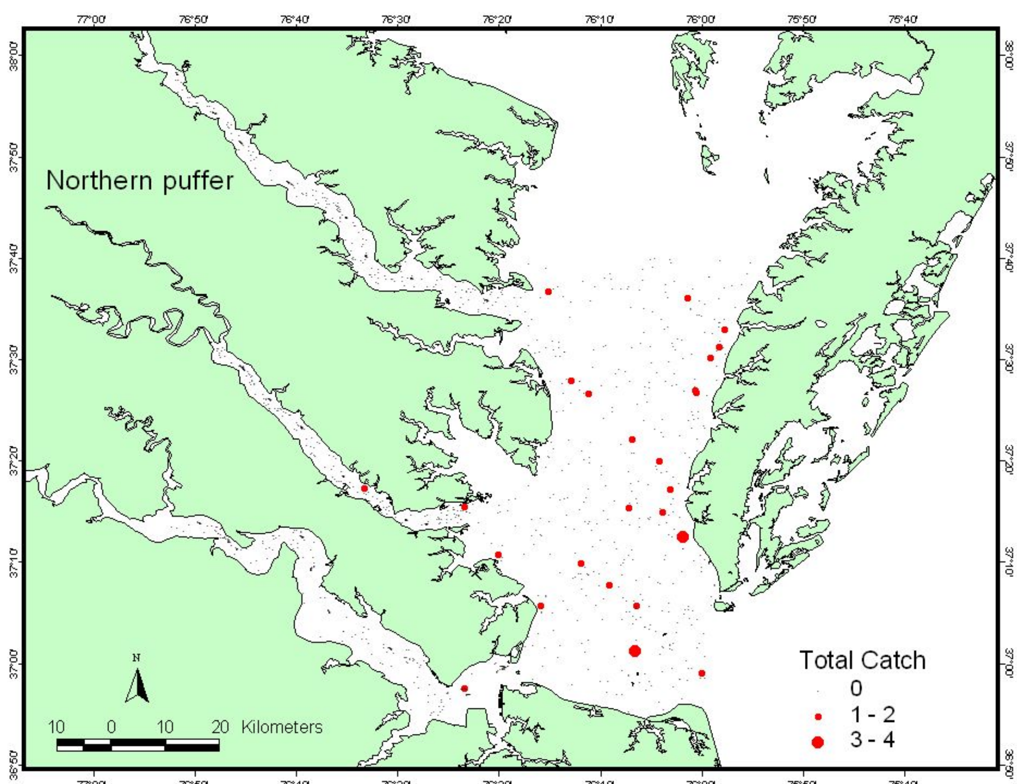


Figure 14. Juvenile northern puffer random stratified index (RSI) and Bay and fixed river station (BRI) indices (Top), and distribution of index-sized juvenile northern puffer from June 2007 through May 2008 (Bottom).

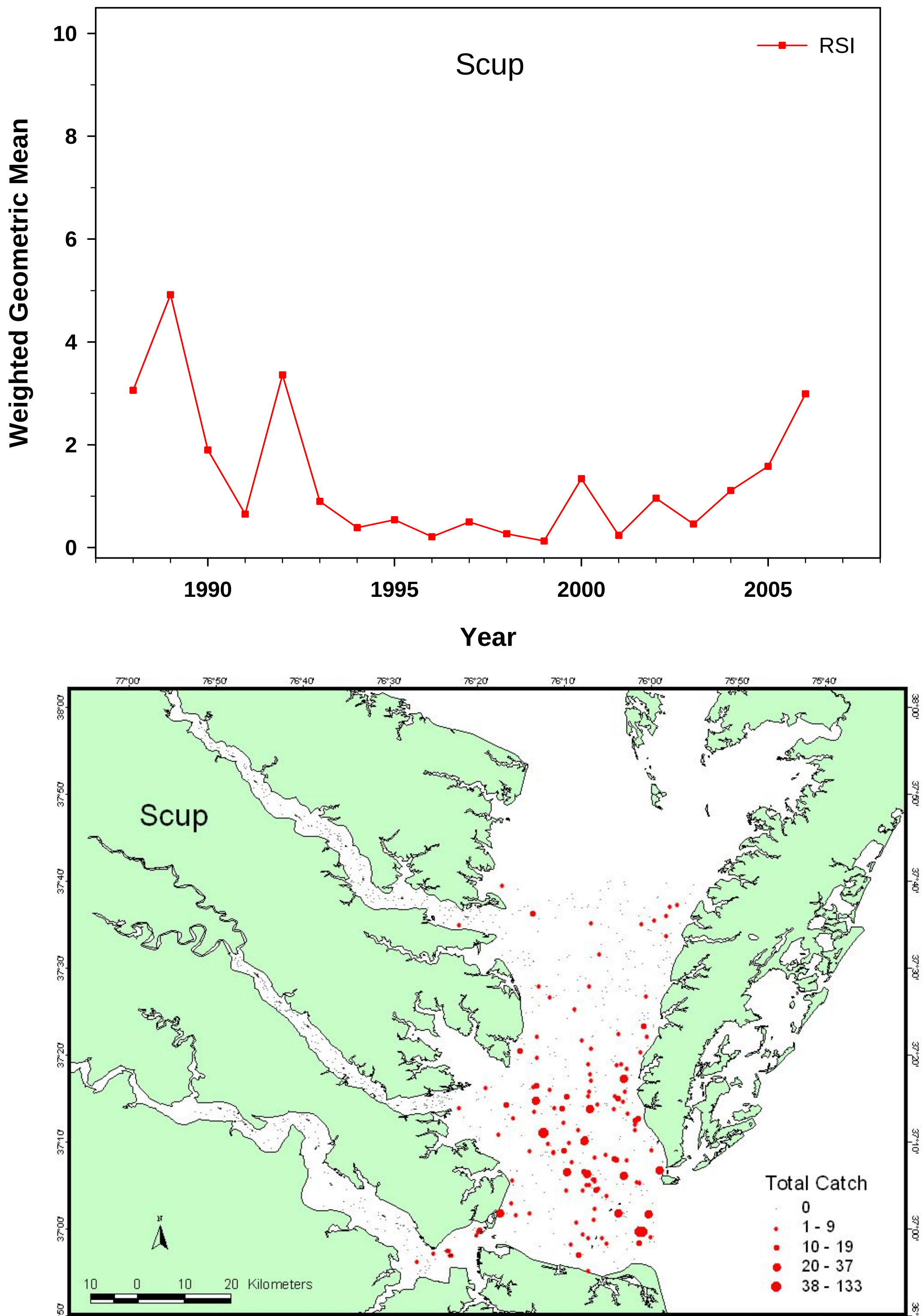


Figure 15. Juvenile scup random stratified index (RSI; Top), and distribution of index-sized juvenile scup from June 2007 through May 2008 (Bottom).

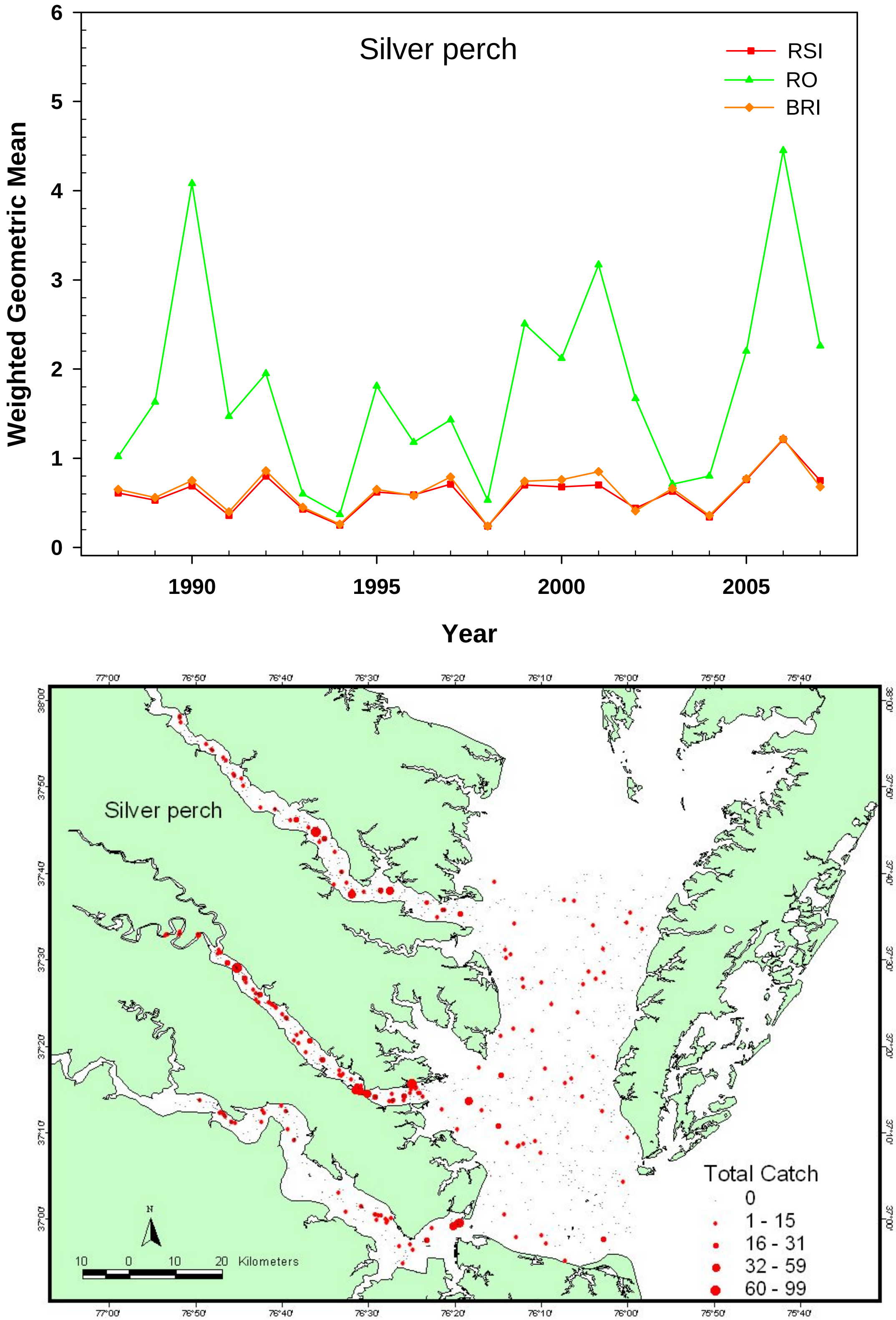


Figure 16. Juvenile silver perch random stratified (RSI) fixed transect (Rivers only – RO), and Bay and fixed river station (BRI) indices (Top), and distribution of index-sized juvenile silver perch from June 2007 through May 2008 (Bottom).

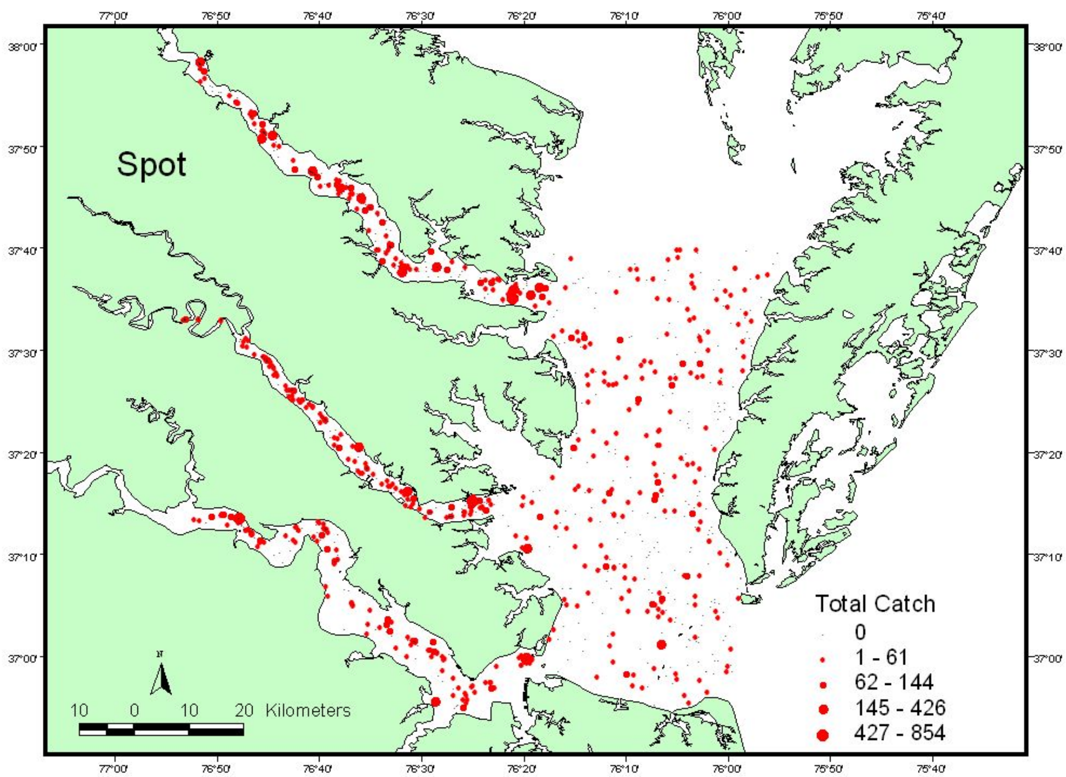
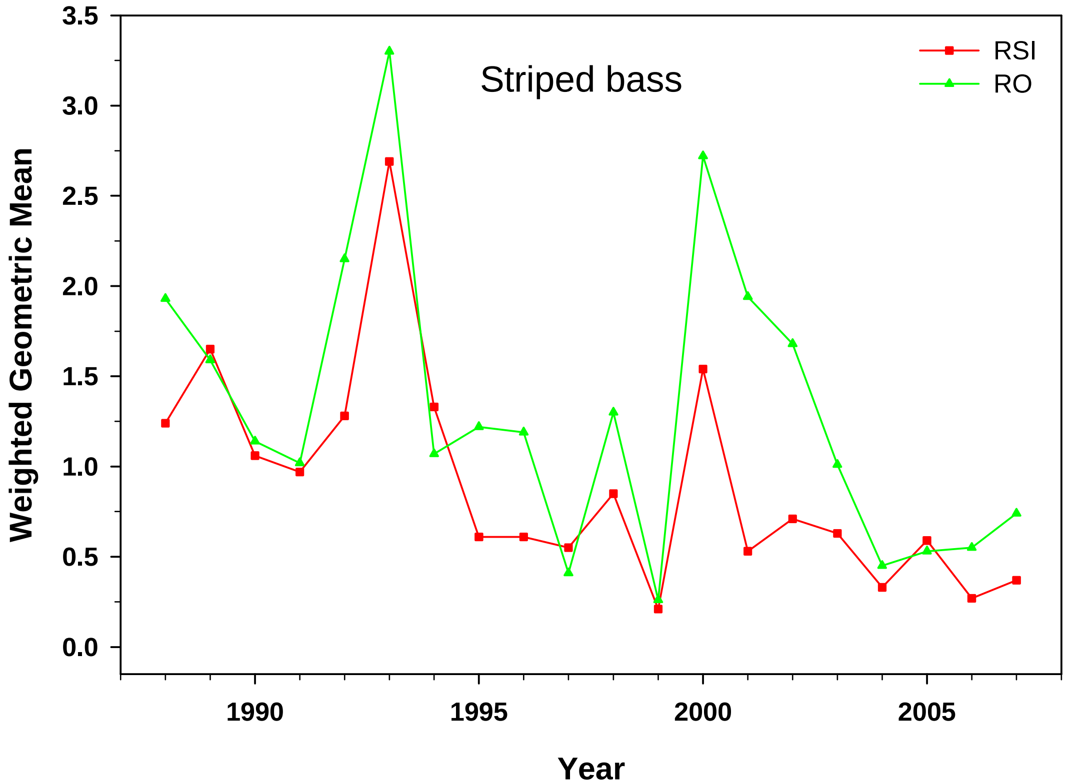


Figure 17. Juvenile spot random stratified (RSI) fixed transect (Rivers only – RO), and Bay and fixed river station (BRI) indices (Top), and distribution of index-sized juvenile spot from June 2007 through May 2008 (Bottom).



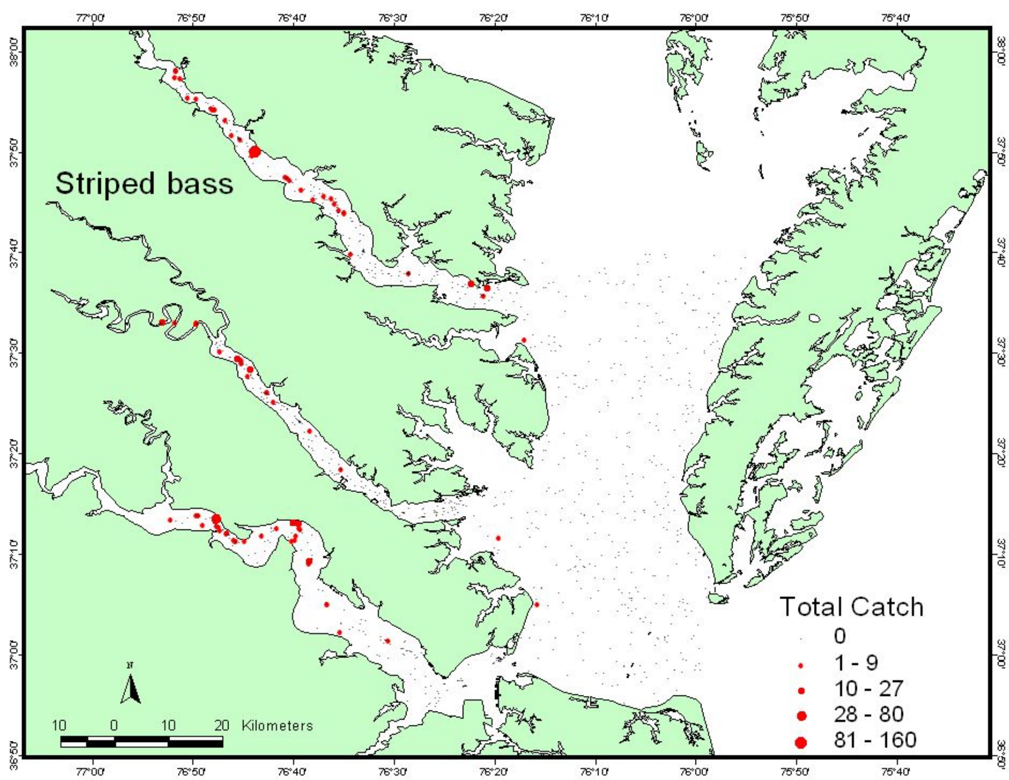


Figure 18. Juvenile striped bass random stratified (RSI) and fixed transect (Rivers only – RO) indices (Top), and distribution of index-sized juvenile striped bass from June 2007 through May 2008 (Bottom).

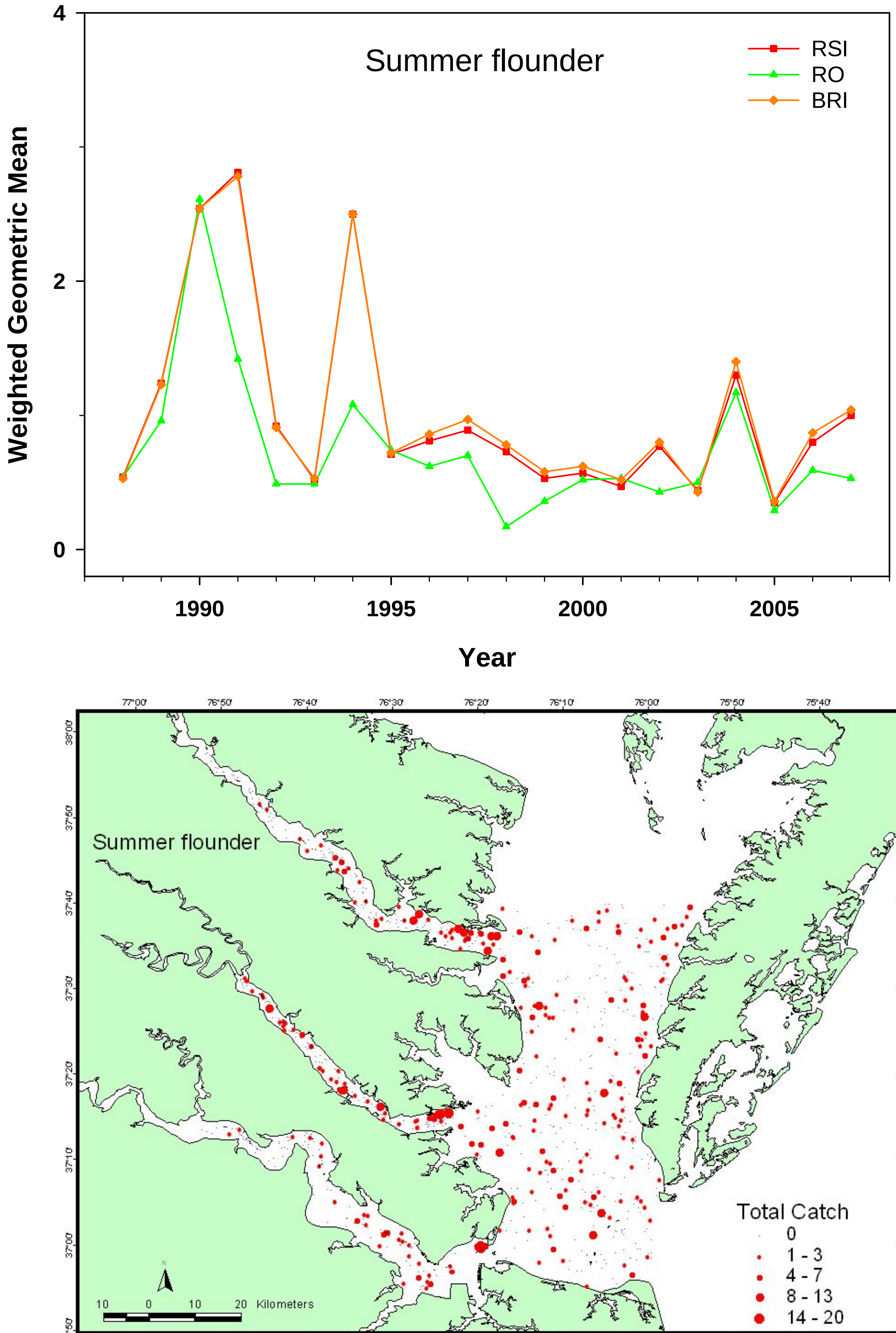
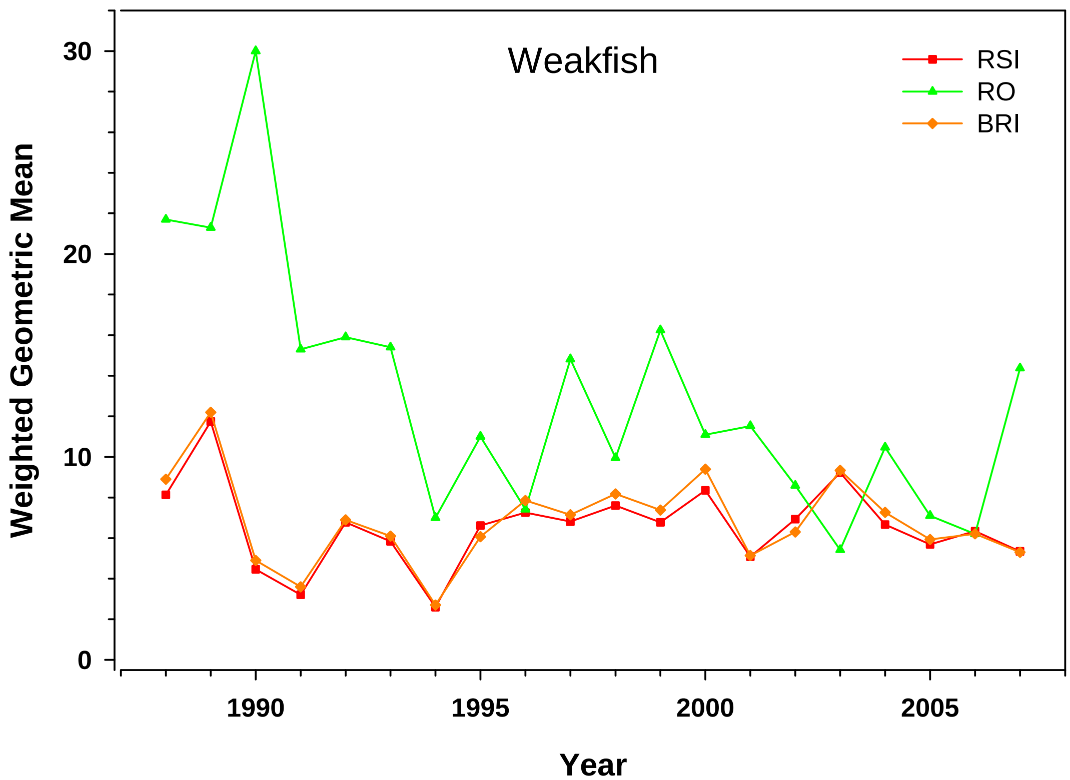


Figure 19. Juvenile summer flounder random stratified (RSI), fixed transect (Rivers only – RO), and Bay and fixed river station (BRI) indices (Top), and distribution of index-sized juvenile summer flounder from June 2007 through May 2008 (Bottom).



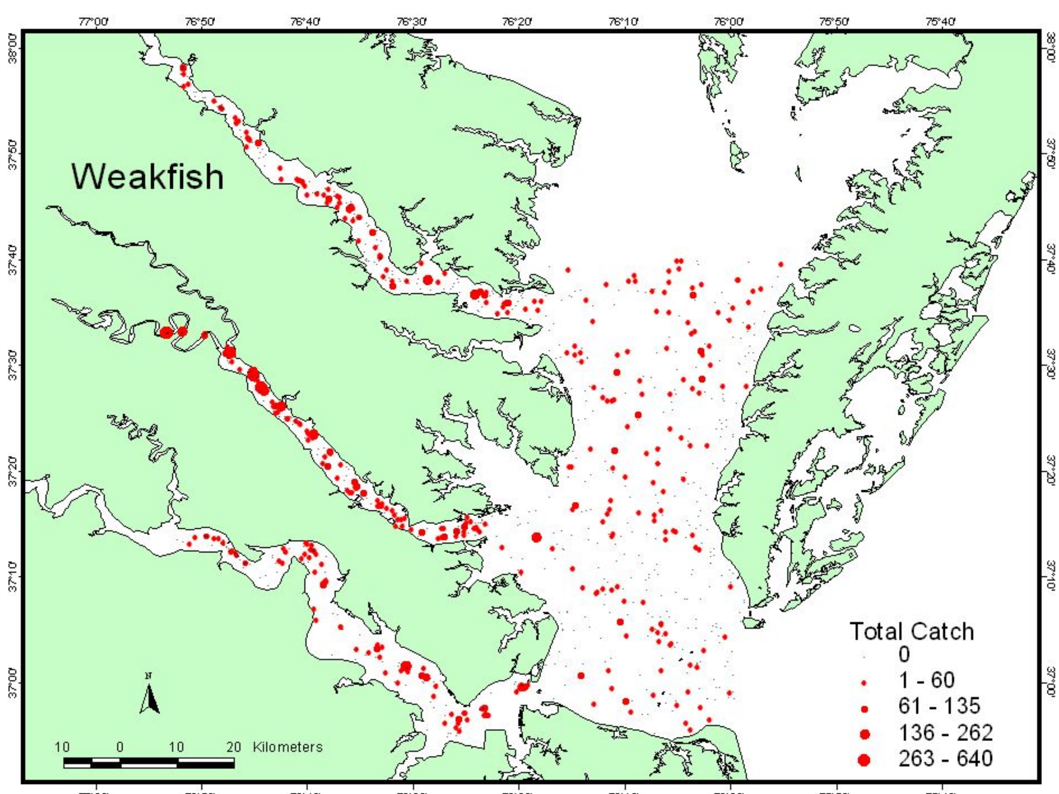
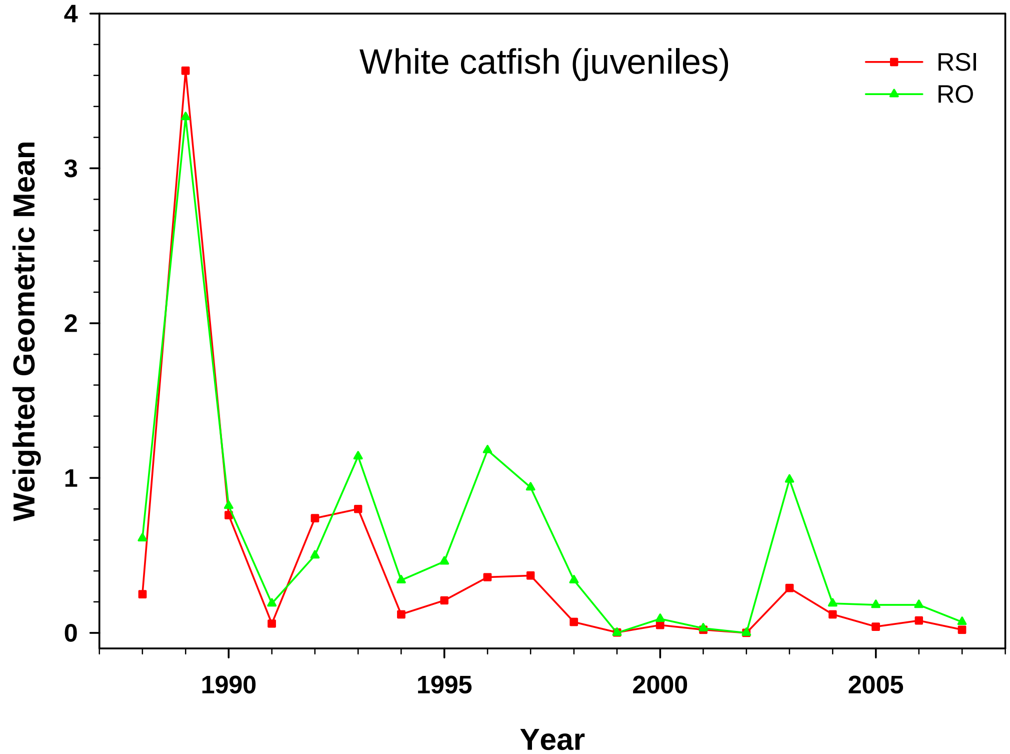


Figure 20. Juvenile weakfish random stratified (RSI), fixed transect (Rivers only – RO), and Bay and fixed river station (BRI) indices (Top), and distribution of index-sized juvenile weakfish from June 2007 through May 2008 (Bottom).



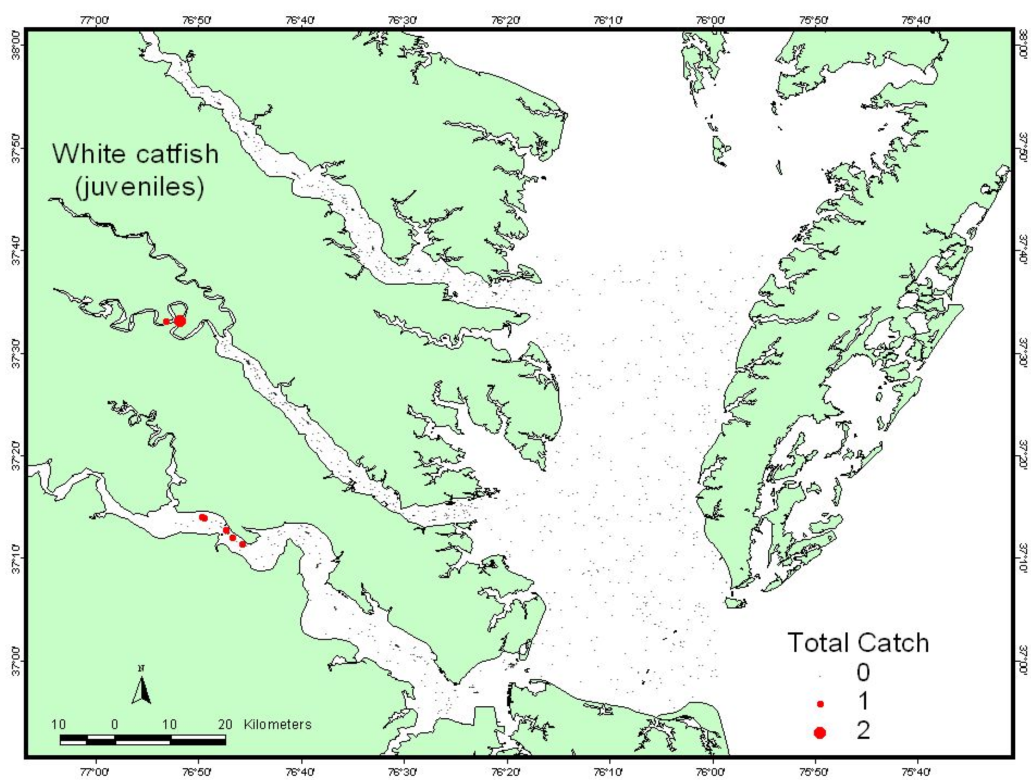
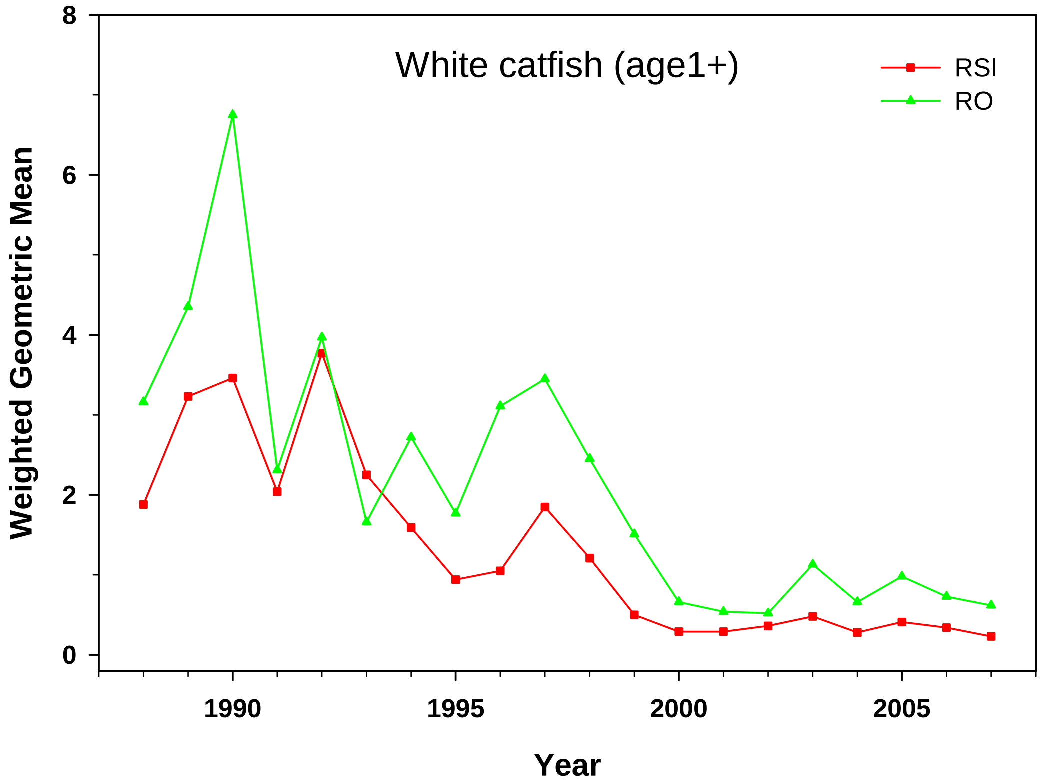


Figure 21. Juvenile white catfish random stratified (RSI) and fixed transect (Rivers only – RO) indices (Top), and distribution of index-sized juvenile white catfish from June 2007 through May 2008 (Bottom).



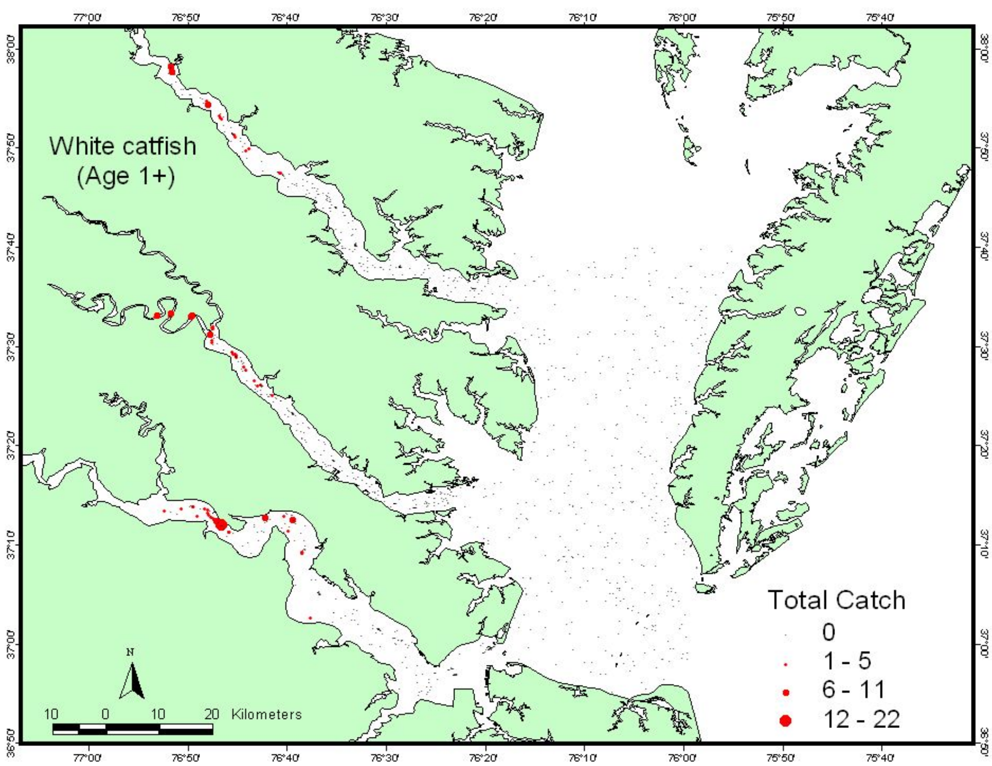


Figure 22. White catfish age 1+ random stratified (RSI) and fixed transect (Rivers only – RO) indices (Top), and distribution of age 1+ white catfish from June 2007 through May 2008 (Bottom).

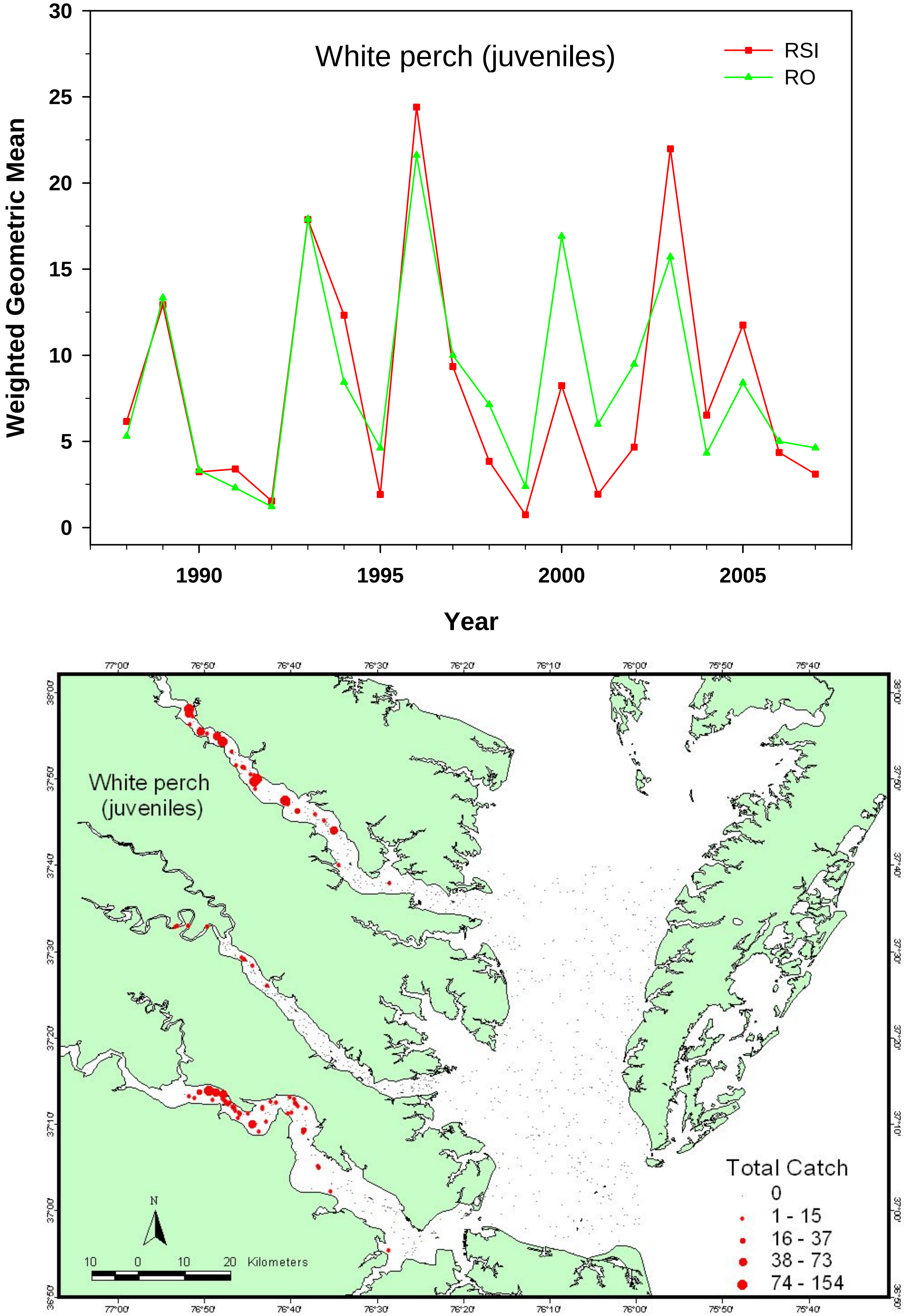


Figure 23. Juvenile white perch random stratified (RSI) and fixed transect (Rivers only – RO) indices (Top), and distribution of index-sized juvenile white perch from June 2007 through May 2008 (Bottom).

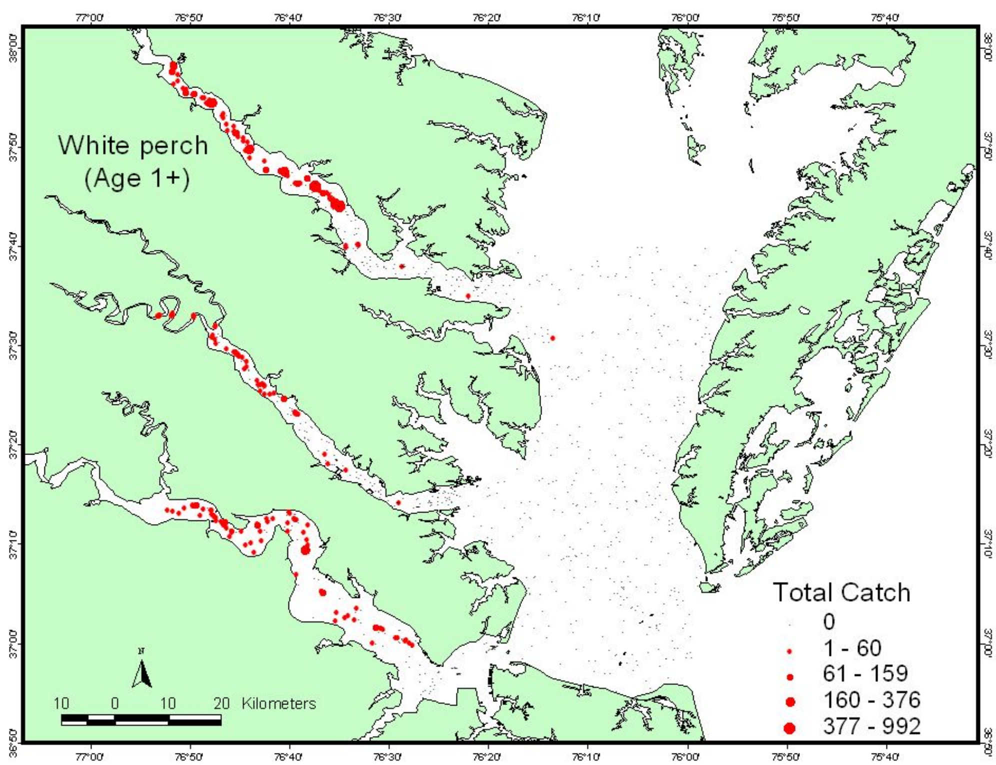


Figure 24. White perch age 1+ random stratified (RSI) and fixed transect (Rivers only – RO) indices (Top), and distribution of age 1+ white perch from June 2007 through May 2008 (Bottom).

Appendix Table 1. Listing of recent Trawl Survey advisory requests

Date	Agency	Nature of Request
6/5/07	Virginia Department of Environmental Quality	Bay mouth station data
6/27/07	Virginia Institute of Marine Science	York River species composition
7/6/07	Naval Facilities Southeast	Elizabeth River stations
7/17/07	Virginia Institute of Marine Science	Fish length data
7/20/07	Old Dominion University	Sheepshead data
7/25/07	Chesapeake Biological Laboratory	White perch hydro data
8/22/07	Virginia Marine Resources Commission	Weakfish data
9/4/07	Elizabeth River Project	Elizabeth River species
9/12/07	Virginia Department of Environmental Quality	Bay mouth hydro data
9/14/07	Old Dominion University	Menhaden data
9/17/07	Elizabeth River Project	Species Richness - Elizabeth River
12/4/07	Virginia Institute of Marine Science	Trawl stations where we collected menhaden, September 2006-January
12/6/07	Massachusetts DMF	LIMNOTERRA Measuring Board questions
12/7/07	VIMS graduate student	Monthly hydro at James station 113
1/22/08	Virginia Marine Resources Commission	2007 Horseshoe Crab data
1/25/08	VIMS graduate student	Rappahannock hydro & striper data
2/13/08	Virginia Marine Resources Commission	Blue Crab lengths 1990 - 2007
3/11/08	Old Dominion University	Adult female blue crab data
3/26/08	West Virginia University	Species Request information
3/28/08	Virginia Institute of Marine Science	Catfish data, graphs, and plots
3/31/08	Virginia Institute of Marine Science	Catfish data
4/11/08	Virginia Marine Resources Commission	Spot indices
5/2/08	Virginia Marine Resources Commission	Croaker indices
5/12/08	Virginia Institute of Marine Science	Blue Crab distribution plots
5/13/08	Virginia Institute of Marine Science	Blue Crab size frequencies